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TEA RESEARCH INSTITUTE

OF CEYLON

THE TEA RESEARCH INSTITUTE
St. Coombs, Talawakele,
Ceylon.

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General.—The laboratories of the Institute are situated at St Coombs Estate, Talawakele, and letters and enquiries should be addressed to the Director, Tea Research Institute, Talawakele. Telegraphic address: Research, Talawakele; Telephone: Talawakele 44 (Private Exchange).

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THE TEA QUARTERLY

Vol. 32 December, 1961 Part 4

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EDITORIAL

Control of Shot-Hole Borer

When I came to the T.R.I. in October, 1959, I found that tea in Ceylon was not greatly affected by pests and diseases. Blister Blight arrived in the Island in 1946, Dr F. R. Tubbs showed how to control it in 1947, and since then the most serious and widespread pest has been *Xyleborus fornicatus* Eichh. This pest seemed to be top priority for making a substantial step forward in the defence of the industry, as distinct from aggressive improvements in culture methods.

The beetle was first recorded from Ceylon in 1868 but the host plant was not then known. It was first recorded on tea in 1892 from Craighead Estate, Nawalapitiya, and it has since been the subject of much research and of a T.R.I. symposium in 1956. How much damage it does was not known, but it was generally agreed to be large. It was for this reason that a special unit was formed in 1955 with the object of inventing a practical control method.

Dr E. Judenko was kindly seconded to us by Messrs Fisons Pest Control Ltd. to lead this unit, first for a term of two years, then for a second tour of three years, and finally in 1960 for a period that was not to exceed two years, it being then uncertain how much longer would be necessary to complete a useful and remunerative programme. During this time, he has confirmed the choice of dieldrin by Mr G. D. Austin in 1954, and the conclusion of Dr B. A. Baptist, from trials on Sanquhar Estate in 1955, that this insecticide does produce a substantial measure of control of Shot-hole Borer; under certain conditions, he found that 1½ lb. of actual dieldrin per acre applied to the lower parts of tea in plucking produced a marked reduction in the peak population that normally occurs 18–24 months after pruning. Judenko also discovered the vital fact that if the wood of the frame is wet at the time of spraying, far larger doses of dieldrin fail to give such effective control.

At the same time, in the Entomology Division under Mr J. E. Cranham, evidence was accumulating in confirmation of the results of Baptist's findings, namely that dieldrin spraying tended to result in outbreaks of Tea Tortrix because of the destruction of the imported parasite of Tortrix *Macrocentrus homonae*. However, on Sanquhar Estate, under the Superintendent, Mr. A. P. Newton (Visiting Agent: Mr W. H. W. Coultas), dieldrin spraying on freshly-pruned frames had come into regular and confident use, though on some other estates results had been variable and sometimes unsatisfactory.

Judenko did not feel that he could make any practical recommendations, because investigations of the aspects listed on p. 115 of the *Tea Quarterly* for 1958 had not all been completed, especially regarding residues in the made tea. Residues from his experiments on tea in plucking were assessed by Messrs Shell International Company, England, and were found to be not large. But, in practice, spraying might accidentally be done with an excessive dose and, if the made tea were then bulked with insufficient uncontaminated tea on the estate, and the bulk not blended with enough other tea before being packaged, a case could conceivably occur of a residue of dieldrin which would not pass properly rigorous standards. However remote such a combination of circumstances might be, the policy decision was taken

not to risk it, because of the damage that could occur to the good name of Ceylon teas, however unjustifiably. It was decided that all future work should be done on freshly pruned frames, carrying no leaf that would ever be plucked and several weeks before the tea would again be plucked. Even so, in early experiments, minute residues of dieldrin were found and further work had to be done to ensure that the levels that might occur were never likely to present a problem.

This change of policy required a new series of experiments, each of which should last a full pruning cycle. But time was passing and, with every passing year, much crop was probably being lost because of the beetles. The question was: should we go on with experiments until we were quite sure of reliable recommendations to make, to cover every contingency? Or should the T.R.I. depart from its usual practice and make provisional recommendations? It seemed to me that we had to consider a gamble, to win additional yield to the industry, especially in the hard-pressed mid-country, but to lose the good name of the T.R.I. if something went wrong. It seemed to me that the surest way for the T.R.I. to lose its own soul in this case was to concentrate on saving it. This conclusion was reached after the fullest discussion with Cranham, upon whom would fall the burden of resolving any complications, and our conclusion was fully supported by the Board and by the Experimental and Estate Committee. We were to make provisional recommendations as soon as we could resolve certain of the complications.

Cranham had by that time worked out how to control Tortrix, using DDT, until *Macrocentrus* could take over control; the residue questions were being cleared up; but scale effects had not been examined and they could be large. That is to say results obtained on small plots need not correspond to results on whole fields, especially in regard to re-invasion by Shot-hole Borer, by Tortrix, and by *Macrocentrus*. It was therefore decided to devote about a year to full-scale trials in co-operation with estates, particularly to cover scale effects with Tortrix and *Macrocentrus*, which ought to become evident in that time. It was realised, however, that the full effects on Shot-hole Borer could not be seen until at least one full pruning cycle had passed.

The time has now come to make the provisional recommendations and this Cranham has done in the following paper. His paper is not intended to be a scientific and historical account of research, with attribution of credit and erudite discussion. It is intended to be studied and understood fully by planters who are troubled by Shot-hole Borer. The proper use of the recommended procedure will require close personal attention by Superintendents. Warnings have been given in various directions but unexpected complications may arise. Cranham and the Division of Entomology of T.R.I. are ready to study and resolve those complications.

Shot-hole Borer in Trees

Commonly a pest of a crop cannot be properly controlled by treating only the crop; the pest continually comes in from other vegetation. For this reason, there has been great interest in the possibility of Shot-hole Borer of tea infesting shade trees in tea and subsequently reinforcing the infestation in the tea itself. There are many species of Shot-hole Borer, which differ little in appearance, only one of which is an economic pest of living tea, so that the matter required skilled technical investigation. Dr Judenko has now shown that, of the shade trees common in Ceylon tea, only *Albizzia falcata* (L) (commonly called *A. moluccana*) certainly harbours breeding and growing stages of *X. fornicatus* and that beetles from this *Albizzia* can transfer to tea and infest it. Dadap is under slight suspicion, but *Gliricidia*, *Albizzia sumatrana* and *Grevillea* can be dismissed.

Polyphenols of Tea

We are glad of the opportunity of giving our readers the latest authoritative account of this subject. No doubt there are many to whom the matter will be so unfamiliar as to be not entirely clear. This is the case with many matters that ultimately affect us greatly. We take our part in advancing and disseminating fundamental knowledge.

Mist-blowers

Of much more immediate practical and financial importance to planters are the following papers. The first, on motorized knapsack mist-blowers records specialized discussions on this type of apparatus and its use, gives the T.R.I. experience, and indicates where improvements might be made.

Polythene Bags

These bags are coming into general use in replanting and the article gives our latest information.

Manuring of Nurseries

Under this heading we give some experimental information and then definite advice. Organic mixtures are still used to a considerable extent, but they are more expensive than inorganic mixtures. If the inorganic fertilizer is applied with due care, especially so as to avoid damagingly high concentrations in patches, and if it is applied with sufficient frequency, it has no disadvantages compared with an organic mixture.

Letters to the Editor

This time, our contributions under this head are from members of the T.R.I staff. We trust that planters are not losing interest in this opportunity of self expression.

THE CHEMICAL CONTROL OF SHOT-HOLE BORER (*XYLEBORUS FORNICATUS* EICHH.) ON TEA

J. E. Cranham

1. Introduction

Experiments on the control of Shot-hole Borer, by spraying the insecticide dieldrin very soon after pruning, have achieved a considerable measure of success. A few estates had already carried out field-scale experiments with this method of control in 1958 to 1959, and a very few estates later adopted it routinely on all pruned fields. In December 1960 the Director announced that the T.R.I. was not yet ready to make a general recommendation, but that we should be glad to give such information as we had to those estates that wished to experiment on their own initiative and responsibility. Accordingly, a mimeographed pamphlet (dated 24th October, 1960) was prepared and copies of this were requested by and sent to a large number of estates and agency houses. In fact, a large number of estates have carried out experiments, most of which have not yet run for long enough to judge the long-term results. The T.R.I. has been engaged on its own trials, and also in co-operating in the lay-out and assessment of trials on fifteen estates where the spraying has been done by the estate. It will be appreciated that there is a difference between the T.R.I. obtaining results in trials and estates obtaining results in practice; the estate trials are intended to provide evidence on results in practice and on a field-scale.

These trials, mostly started in 1960, have also not run long enough to assess the results fully, but most of the initial results on control are promising. In addition there is earlier evidence of the value of dieldrin in controlling Shot-hole Borer from estate sprayings done in 1958 and 1959 and from the experiments of Dr Judenko on spraying the basal parts of tea bushes in plucking (Judenko 1958, 1960). Not all of these results have been good but there is now no doubt of the effectiveness of dieldrin in controlling Shot-hole Borer when sprayed to give good coverage on dry bark, and there are cases where the control has already lasted for three years. However there is still doubt about the length of time for which control will be obtained under a wide variety of conditions, and we have to await the full result of the T.R.I. estate trials started in 1960. It is intended to publish the interim results in the Tea Quarterly for March, 1962.

With regard to the Tortrix side-effect, we are satisfied that this is due to a temporary unbalance in the normal parasitic control by *Macrocentrus homonae* and in every case observed so far the natural control has been restored, in most cases without serious damage by Tortrix (Cranham 1961). Further, the use of DDT in controlling Tortrix has worked out better than we could have reasonably expected, because not only has DDT proved effective in control but also it does not interfere with the re-establishment of *Macrocentrus*. The Tortrix side-effect is not therefore serious enough to bar the use of dieldrin. No other widespread side-effects have been observed by us, though a few isolated cases of increase in other pests, probably due to dieldrin, have been noted.

In these circumstances, when Shot-hole Borer is such a serious pest in the mid-country and parts of the low-country, and when so many estates are experimenting on a fairly large scale with this method of control, we feel that the T.R.I. should make a definite statement of such guidance as we can give.

We recommend the use of dieldrin on the lines to be given below, *with certain warnings and provisos, to which we ask you to give your careful attention.* We suggest that estates that have not experimented before with its use should not rush in headlong and spray all pruned fields, but that they should go carefully and spray a field or two to begin with. It is reasonable for those estates that have already obtained good results on a field-scale to go on to routine use on all pruned fields.

The natural balance of pests and parasite on tea is a valuable heritage, as yet largely undisturbed by the use of pesticides (Cranham 1961) and it is not without most careful thought, and a great deal more evidence than can be given here, that we now recommend the use of the persistent insecticide dieldrin for the control of the most serious insect pest of tea, Shot-hole Borer, because all cultural and other methods of control have failed. It is virtually certain that dieldrin will cause changes in the insect fauna of tea but it does not follow that such changes will be economically important or, in the total result, injurious. Some, such as the partial control of scavenging termites, may be beneficial. The use of dieldrin is a calculated risk—like much in tea planting—and, in making this initial recommendation, we have done all we can so far to calculate the risks involved. Our job is far from finished—the continuous appraisal of the many aspects of results, and work on refinements of the method, must necessarily go on.

In this work we have been greatly stimulated by the enthusiasm of many planters, and we express our sincere gratitude for their very real co-operation—long may it continue! With these thanks, and warnings, we wish you success in controlling this injurious pest, and express the hope that these measures will contribute appreciably towards a better economy of mid-country estates.

2. The method and how it works

In essence, the method is simple: a dose of 6 pints of 'Dieldrex 20' (or 'Dieldrex Extra') in about 100 gallons of water per acre is sprayed on the dry bush-frames very soon after pruning and before bud-break.

Shot-hole Borer breeds mostly in the young wood, between one-quarter and one-half inch thick; normally the rate of increase is greatest in the early part of the pruning cycle, after the new wood becomes thick enough for galleries. Peak numbers are usually reached in the latter part of the second year and then numbers decline, but sufficient continue and later survive in the pruned frames to increase again in the next pruning cycle. Dieldrin spraying after pruning gives a high degree of control of the beetles and young stages of the borer left in the pruned frames, thus leaving very few to increase in number again in the next pruning cycle.

It has been shown that there is a sharp decline in numbers even within the first few weeks after spraying (Cranham 1961a), but we do not yet know how much of the total efficacy of the dieldrin is attributable to its persistence beyond the first 2 or 3 months.

Shot-hole Borers do of course disperse and reinfestation of the sprayed area from outside is a factor to be taken into account. We still know very little about the dispersal of this insect, but evidence so far suggests that it is quite slow and that,

in their effect on how long control will last, the numbers left on the field after the spray has done its work are more important than reinfestation from outside by immigration of beetles.

If this is so, it is very fortunate, but it does mean that spraying must be very effective initially and two points need stressing—*spray only on dry bark* and see that there is *excellent supervision.* If bushes are missed, or control is patchy because some was done in wet conditions, these will provide foci of infestation from which numbers can again build up, and this is likely to prove more important than reinfestation from outside. Naturally, the bigger the continuous areas that are treated with dieldrin, the less important will reinfestation be but we also have to consider the immigration of the parasite of Tortrix *Macrocentrus homonae* (*see* Section 4 below).

There was reason to hope that if we could obtain control of Shot-hole Borer for two years, the wood (regrowth from pruning) would afterwards be much less suitable for the breeding of Shot-hole Borer (Gadd, 1949). Some recent evidence, however, shows numbers on sprayed areas, which were small in the second year, to be increasing in the third year. We now have to answer the question: is the normal decline in numbers after a peak due to the wood becoming unsuitable as it ages, or does the wood simply become unsuitable due to overcrowding of shot-hole-borer galleries? Many data will have to be obtained to answer this question.

The practical issue is that with 2-year pruning cycles, spraying can if necessary be done after every pruning, but with 3-year or 4-year cycles, there may be a build-up in numbers in the latter half of the cycle and, if this happens, we cannot contemplate spraying dieldrin on the frames of tea in plucking—the risk of residues of dieldrin in made tea, which are not permitted by importing countries, is too great, even if the tea is put temporarily out of plucking. *Under no circumstances should spraying be done of tea in plucking.*

We do not yet have a general picture of long-term control. There is no reason to be pessimistic; indeed, in some instances, there is evidence of control being still good after three years. The observations do, however, again stress the need for the initial spraying to be done as well as is possible.

The method is not perfect nor is it very convenient, although the results to be obtained are worth the trouble. We are well aware that most pruning is done in wet seasons when it is not easy to find days when the bark is completely dry and, indeed, may be impossible in districts such as Lower Dickoya or Ratnapura. However, pruned frames dry out remarkably quickly and some promising results are being obtained even in these districts. We will go on trying to find the best and most convenient method for these districts. Again, spraying at 100 gallons per acre with knapsack sprayers is slow and tedious, and it may be difficult to get good coverage even with 100 gallons per acre when the frames are very large or the number of bushes per acre is large. To meet these difficulties, we are doing work which is described under Section 7.

3. Dieldrin spraying

Dieldrin is sprayed soon after pruning on the dry bush-frames, and the essential details are as follows:—

3.1 The insecticide

The Shell Company of Ceylon, Ltd., supplies 'Dieldrex 20' and 'Dieldrex Extra'; both of these formulations contain 20% w/v of the insecticide dieldrin

(2 lb. per Imperial gallon). 'Dieldrex Extra' also contains a resin which is said to give greater persistence of the insecticide, but no difference in the control obtained has yet been proven. 'Dieldrex 20' is a little cheaper per gallon. It is not yet known whether 'Dieldrin 50% Wettable Powder' is effective.

Either liquid formulation may be used on clean-pruned mature tea, but where foliage remains, as on young tea, or after lung-pruning or pre-pruning, we at present advise 'Dieldrex 20'.

3.2 Dosage

The dose to be applied for mature and adolescent tea is one round of 6 pints of 'Dieldrex' (1.5 lb. of actual dieldrin) per acre. This must be applied in a sufficient volume of water to cover the bush frames thoroughly and, using knapsack sprayers, this is generally about 100 gallons per acre, depending on the size of the bush frames. There is only one round of spraying to be done and it must be done very well.

If you can genuinely obtain good coverage with less than 100 gallons per acre, use the 6 pint dose in whatever volume of water is used per acre, *e.g.* in 70, 80 or 90 gallons per acre.

If you have to use more than 100 gallons per acre because of large bush frames or a large number of bushes per acre (*e.g.* 5,000 or more per acre) use the concentration of 6 pints per 100 gallons and use more of it.

Only for very young tea, which represents much less wood to spray, or for fields with an unusually low number of bushes, due to vacancies, use the concentration of 6 pints per 100 gallons and use whatever volume is necessary to cover the frames thoroughly; this should never be less than about 50 gallons per acre.

N.B.—Previously, we have suggested two spraying rounds of 3 pints per acre at a three-week interval, as an alternative. This can be used, but results so far suggest there is no advantage in two rounds, and it is easier to find one dry day than two, and one round requires less labour and supervision.

3.3 When to spray

Spray as soon as possible after pruning so that spraying is completed before bud-break occurs. This varies from about one month after spraying in the higher mid-country to only two weeks or so in the low-country. Experiments have shown that the effect of dieldrin is very much reduced if sprayed when the bark of the frames is wet, and it is important that spraying should be done when the bark is dry and that the deposit should dry on before rain occurs. If it rains after spraying has been begun, spraying should be suspended until the frames are dry again. The occurrence of rain after the deposit has dried on is thought to be less important, although continuous very heavy rain may reduce the degree of control obtained. If spraying is delayed owing to the weather, it may still be done when buds are just about to break, *i.e.* there is a latitude of about one month after pruning in the mid-country, but less in the low-country. Do not spray any later than this (*see* Section 3.7 below).

Prunings must either be removed, stacked in drains or, if small, packed down well between the rows, in order to allow free access to the sprayers. It may be desirable after pruning to wait before spraying until the leaves on the prunings have dropped, but the most important criterion is the weather.

3.4 How to spray

On clean-pruned tea, or after cut-across pruning, spray the whole frame thoroughly from above and from all sides to cover all the bark, including younger wood, the trunk, and the main branches. Where pre-pruning or lung-pruning are done, spray the whole of the frame to the height of the prune, but not the foliage. If pre-pruning is done, spray soon after the pre-prune; plucking of the unpruned halves of the bushes *must* be stopped after spraying, since contamination with dieldrin is unavoidable and dieldrin-contaminated leaf must not be manufactured (*see* Section 3.7 below).

In new clearings, spraying is best done after a cut-across or prune, unless serious attack occurs when the plants are still very young and pruning should not be done. It is desirable to cover all wood from the base up to wood of pencil thickness, though this is sometimes difficult because of the lower foliage, and this will get sprayed too.

N.B.—We do not recommend that pruning should be altered in time or type to suit the spraying, if there is a danger in so doing. Prune the bushes in the way that is culturally best.

Most types of knapsack sprayers are suitable. Pressure-retaining sprayers, particularly with pressure regulators, are most suitable for uniform output and spray economy. It is necessary to spend several seconds on each bush to obtain good coverage, spraying downwards from above and upwards from all sides, so that nozzles giving a fairly low rate of output will economise spray fluid. Whereas fan jets are suitable for blister-blight spraying, nozzles giving a cone of spray are more suitable for most insect control. The following nozzles of certain popular makes are considered very suitable:—

Make	*Nozzle*	*Approximate time of output of $2\frac{1}{2}$ gallons at 55 lb pressure*
Birchmeier	'Duro', 1 mm. disc	21 min
Birchmeier	'Horto-Sapphire', 0.9 mm.	28 ,,
Favori-Colibri	No. 520, disc 214/8	21 ,,
,, ,,	,, ,, disc 214/10	18 ,,
Four-Oaks	'Duiker' No. 2	28 ,,

For other makes, use nozzles giving a cone of spray and similar output times. The time is required to obtain good coverage of all the bark.

3.5 Supervision and training of labourers

It cannot be emphasised too strongly that *good supervision is vital.* This is not like blister-blight spraying; there is only one round and every bush must be thoroughly sprayed.

Labourers can be trained by spraying water. A simple calculation will show that at 100 gallons per acre, a tank of $2\frac{1}{2}$ gallons must cover from say 50 bushes (density of 2,000 bushes per acre) to 100 bushes (density of 4,000 bushes per acre). The volume required increases somewhat with the bush density, but not in proportion.

The labourer has, therefore, for example 20 minutes (1,200 seconds) for 100 bushes and he can spend an average of 12 seconds on each bush. This gives an idea of what the pace should be, and it is worth checking in the first instance how many bushes are in fact being covered by one tank.

Alternatively, mark off one-fifth acre plots (*see* Section 7.1 below) and check that the right amount goes on each plot. This is suggested for training labour, but it would have merits as a routine.

A great aid to supervision would be a clearly visible deposit (*see* Section 7.2 below).

3.6 Caution—safe handling of dieldrin

Dieldrin has been very extensively used in agriculture and in public health work, with a good record of safety as regards any hazard to the spray operators. Nevertheless, insecticides are poisonous and dieldrin is one that can be absorbed directly through the skin in harmful quantities. Due care should be taken in handling it and superintendents are strongly advised to acquaint themselves with the manufacturer's advice on handling, and especially to arrange for adequate supervision to prevent misuse. The common-sense measures recommended are as follows:—

(*a*) keep dieldrin formulations in labelled containers, away from food and out of reach of children and animals. Empty cans should be punctured and buried so that they cannot be used for drinking water, etc.;

(*b*) when handling or mixing the concentrate, avoid spilling it on the skin and keep it out of the eyes, nose and mouth. If any is spilled, wash it off the skin and clothing immediately;

(*c*) *wash thoroughly with soap and water* before eating or smoking and at the end of the day's work;

(*d*) it is highly desirable to provide labourers with spraying clothes, which they change after work, and to have these washed regularly. A piece of hessian tied round the waist to cover the legs will prevent a good deal of skin contamination, provided this is discarded or washed when it becomes contaminated;

(*e*) apart from gross contamination due to misuse, it is very unlikely that workers can have any genuine ill-effects except after prolonged working exposure. It is therefore wise, if extensive spraying is being done more or less every day, to switch spraying gangs after a month; the relieved gang should then be out of all contact with dieldrin for a month before being put back on to spraying;

(*f*) to protect fish and animals, be careful not to contaminate streams or ponds with dieldrin. Do not clean spray equipment or dump excess spray material near such water. Dig a hole and bury it;

(*g*) in the unlikely event of the insecticide being swallowed, induce vomiting by giving one tablespoonful of salt in a glass of warm water; and repeat until vomit fluid is clear or the odour of the solvent is gone. Have the victim lie down and keep quiet, and call a physician immediately.

3.7 Residues in made tea

Residues of dieldrin in made tea are not permitted by importing countries and could be dangerous. Do not allow tea in plucking in adjacent fields to catch chance spray or drift. Spraying of tea in plucking should *never* be done and spraying should not be done later than recommended (*see* Section 3.3 above).

3.8 Costs

The cost of chemical per acre (6 pints) is about Rs. 30/-, varying slightly with the quantity purchased. Generally, 4–5 labourers per acre are required; the nozzles recommended are of fairly slow output and ten loads of $2\frac{1}{2}$ gallons, plus refilling time, per labourer per day, is quite good. Thus the labour cost is usually Rs. 10/- to 12/- per acre. There is also the matter of labour for stacking or packing down prunings. Together with the cost of spraying DDT (*see* Section 4.4 below) the total cost per acre is of the order of Rs. 60/-, two-thirds of which is for insecticide. On a two-year pruning cycle the cost of control is thus only Rs. 30/- per annum, which should be well worth while on the benefits gained.

4. DDT spraying and Tortrix

Tortrix oubreaks have occurred in such a large percentage of sprayings that we recommend spraying DDT as a routine prophylactic, not only when Tortrix is seen. It is important that planters should be particularly *vigilant* in looking for Tortrix on dieldrin-sprayed areas, or indeed for any increases of other pests which might be due to dieldrin. Vigilance is the price of freedom from pests. Permit a few Tortrix, which will help to support the parasite *Macrocentrus*, but if an outbreak does occur again after the DDT spraying, do not hesitate to use DDT again—this should rarely be necessary. Do not allow Tortrix to spread to other fields from an outbreak, which it can quickly do. The use of DDT will not interfere with the natural re-establishment of *Macrocentrus*, which is usually achieved about four months after spraying dieldrin (Cranham, 1961).

It is of course necessary that *Macrocentrus* should be available on adjacent unsprayed tea, so as to hasten its re-entry of the sprayed area to recover natural control of Tortrix. For this reason, it is desirable that sprayed fields should border unsprayed fields, or fields sprayed more than six months previously, on at least one side. There have also been indications that *Macrocentrus* can come in from adjacent jungle, but not from patana. This restriction does not prevent one from spraying large continuous areas of many fields over a period of time—and this will reduce the re-infestation by immigration of Shot-hole Borer from outside.

Never put tea out of plucking because of Tortrix; this will make the attack worse; plucking is a partial control measure. Markedly higher rates of dieldrin than those recommended are liable to lead to worse Tortrix attacks.

Damage from Tortrix is worst in the early stages of recovery from pruning; later a small number of Tortrix per bush will not be serious. It has been noted that it can be particularly nasty, where pre-pruning is done, on the young re-growth from the secondary prune.

4.1 Insecticide

Emulsion formulations of DDT are recommended, including the following:—

Supplier	*Trade name*	*Percentage DDT*
I.C.I. Ltd., & Agents	'Didimac 25' liquid	25%
Fison's (Ceylon) Ltd.	'Sillortox'	25%
Shell Co. of Ceylon, Ltd.	'Arkotine D18'	18%
A. Baur & Co. Ltd.	'Deenol 25'	25%

4.2 Dosage

The rate recommended is 4 to 6 pints per acre in 50–60 gallons of water applied to cover the maintenance foliage from above. Use the higher dose of 6 pints for bad attacks or for dense bush stands.

4.3 When to spray

Apply just after tipping, or earlier only if a bad attack develops before tipping. The foliage should be dry at the time of spraying and the deposit should dry on before rain occurs. With pre-pruning, apply it just after the secondary prune and, on new clearings, two months after the dieldrin spray. This should prevent a build-up of Tortrix, but if one does occur later, DDT may be used on tea in plucking. It is necessary to spray just after a plucking round and to discard the following (one) round. DDT will not taint or affect quality; the discarding of one round is necessary to minimise DDT residues in made tea.

N.B.—We are experimenting with the use of DDT applied with the dieldrin on clean-pruned or cut-across pruned tea instead of separately. No recommendation can yet be made. This method cannot apply to pre-pruned or lung-pruned tea, since the type of spray coverage required is quite different, *i.e.* DDT has to cover the foliage and dieldrin the bark.

4.4 How to spray

Apply so as to cover the maintenance foliage effectively from above and the sides. It is not necessary to put the nozzle under the foliage and spray upwards. This spraying can be done much more quickly than the dieldrin spraying. Use the same nozzles, or better, use the same nozzles with larger discs, or use double nozzles.

Make	*Nozzle*	*Approximate time of output of 2½ gallons at 55 lb pressure*
Birchmeier	Double 'Duro', 1 mm.	12 min
	Single 'Duro', 1.5 mm.	12½ ,,
Favori-Colibri	No. 520, double, discs 214/10	9 ,,
	No. 520, single, disc 214/15	12½ ,,

DDT is less toxic than dieldrin but the same common-sense care should be used. The cost for chemical is about Rs. 10/- to 12/- per acre, and for labour Rs. 5/- to 7/- per acre.

5. Records

For future reference, it is wise to record the following details of spraying:—Field No., acreage sprayed, date of pruning before spraying, dates of spraying, amount of dieldrin used (*x* pints of 'Dieldrex' per 100 gallons water sprayed at *y* gallons per acre), labour used, and costing, DDT used, dates of spraying, dosage used, labour and costing. Weather details (for dieldrin and DDT spraying):

Were the bushes dry before and during spraying?

Did heavy rain fall on the same day after spraying, or was there intermittent rain or drizzle?

The rainfall and sunshine figures, if available, for the weeks subsequent to spraying.

It is useful also to record the dates when Tortrix may be first noted and keep notes on the attack.

6. Assessment of results

6.1 Control of Shot-hole Borer

It is usually at least six months and often nine to twelve months from pruning before the occurrence of shot-hole-borer galleries in the *new* wood can be assessed. Note that the galleries in the old wood do not heal up internally although the openings usually heal over. The full effect of control can be judged only after two years or more. It is quite easy for a planter to make a rough assessment of new attack at any time by cutting out new striped wood of branches that are ¼ inch to ½ inch in thickness and splitting it down to examine for galleries. A minimum sample of hundred pieces taken from all over a field should be examined, and unsprayed and sprayed areas can be compared. The percentage of pieces with galleries is a useful measure of accumulated attack at any time.

6.2 Yield—Increase in crop

There will naturally be a great deal of interest in the increase in yield which may be obtained by controlling Shot-hole Borer. The precise evaluation of yield differences requires detailed replicated trials, which we are doing. We do not have sufficient data yet to know what the general trend may be; in any event there are likely to be wide local variations in response. There will not necessarily be an increase in the first cycle after spraying, though in some cases this seems to have occurred (*see* Newton, 1960).

A word on how you assess crop figures may be timely. It is possible to compare green crop weights on a basis of pounds per acre for large sprayed and unsprayed plots in the same field, if the surveyed acreages of the plots are known. However, natural differences in yield between different parts of the same field can be very large, even if not obvious, and such data mean very little unless plots can be individually pre-assessed for yield for at least several months before spraying.

Equally, you may reach erroneous conclusions if you compare the crop from a field in the present cycle with the crop in previous cycles. There may be a marked difference but without a control area we have no idea how much of this is due to treatment, if any at all. This sort of comparison is valid only if we compare the yields of several sprayed fields and of several unsprayed fields with the yields of their previous cycles. Even then it is not precise, but it can provide a better practical assessment than the other methods, and it is an abundance of this sort of data, that can provide us in the long run with an assessment of the yield increases obtained under a wide variety of conditions.

6.3 Bush frame and starch reserves

Shot-hole Borer is believed to be a primary factor in the mid-country which sets in progress a vicious circle of deterioration of starch reserves and maintenance foliage, die-back, sun-scorch and wood-rot. Just how big a part Shot-hole Borer plays in this chain of events is not known at all clearly because previously it could not be controlled. Obviously it is not the only important factor at work in reducing starch reserves; for instance, the type of pruning and adequate manuring are vitally important. It is to be expected, however, that control of the Borer will greatly improve the bush frames and maintenance foliage, leading in time to a better level of starch reserves, with a lessening of the concommitant troubles that affect bushes with low reserves—die-back, sun-scorch and wood-rot. This is to be expected provided that other important cultural factors are not limiting; the response under a wide variety of conditions remains to be seen, although some promising results have already occurred in mature tea and particularly in new clearings.

It is suggested that if bush frames that have been reduced over the years to a poor rotten condition are to be slowly re-built, this must be done by a process of selectively pruning out poor wood over two or three pruning cyles rather than any drastic pruning that is more than the existing reserves will cope with.

We will be glad to know about planters' observations on these aspects.

7. New developments in the method of control

In this section, we deal with experimental work going on which we hope will make the method of control less tedious, more convenient, or of wider usefulness, or perhaps more effective, or with less Tortrix side-effect.

7.1 Mist-blowers

Motorised knapsack mist-blowers are a fairly recent innovation for spraying Ceylon tea (*see* Cranham, 1961b for details of machines, and Elias, 1961 on blister-blight mist-blowing). There is a very definite possibility that mist-blowers may provide the most convenient, economical and perhaps the most generally effective means of spraying dieldrin for the control of the borer. The principle is to apply the same dose of dieldrin (6 pints) in much lower volumes of water per acre, say 10 gallons. The advantages of this method are:—

(*a*) greater speed of operation, so that there is a better chance of doing spraying on the available dry days;

(*b*) reduced labour cost per acre, and less carriage of water;

(*c*) where frames are large, or awkward to spray at high-volume, or the bush density per acre is high, adequate high-volume coverage requires a bigger volume of the same concentration and therefore more dieldrin per acre. Mist-blowing provides the most convenient method of obtaining reasonable coverage of such frames and, if there is more wood or bushes, then more of the mist impacts on them. Mist-blowing does not require a bigger volume or dose per acre; it is ideally suited to dense planting, which also minimises drift;

(*d*) with high-volume, it is necessary to walk in every row and prunings can get in the way. For mist-blowing, prunings can be stacked down between the rows in every alternate row and the sprayer travels on every other row.

There is also a distinct *possibility* that the requirement of dry bark for high-volume spraying is not so stringent for mist-blowing. There is no run-off. Provided the spray dries on before any rain occurs, it may be possible to start earlier in the morning on damp bushes and not have to wait until they dry out, as one does have to do with high-volume spraying. This is not certain but the above are the reasons why we are interested in mist-blowing.

There is one big danger—*drift* of the spray mist contaminating tea in plucking. Experience so far suggests, however, that this is greatly reduced in dense plantings, for which the method is most useful; the advantages over high-volume spraying in fields with a lot of vacancies are not so pronounced. On the edges of fields which adjoin tea in plucking, it will be necessary to spray the edge by high-volume, especially if the wind is blowing on to the tea in plucking. This, however, does not rule out the use of mist-blowing on the major part of the field.

Of course, wind is the enemy of mist-blowing. It can be done perfectly well in a light wind but should not be attempted in strong winds. As a general guide, if the spray will not reach two rows against the wind, give up spraying that day.

The details of the method being experimented with, which it is hoped will prove a working method, are as follows:—

All knapsack mist-blowers may be used. The lighter machines with engines of about 1 h.p. or less, and with air outputs of about 150 cu.ft per minute, appear to be quite satisfactory, although the machines with the bigger engines and air outputs may have advantages in giving wider coverage; this is not yet determined. A short lance is desirable for easy management in most tea, and there must be a device such as a reducing jet, for fixing the rate of liquid output so that it cannot be altered by the labourer when he is spraying. He should have only an on-and-off tap on the lance. The 6-pint dose per acre is applied in ten gallons of spray solution. For training labour, the method here described can be used and this has merits as a routine method too.

1. In row-planted tea, mark off by four corner stakes a more or less square plot 30 yards up the rows by 32 yards across, *i.e.* in 4 foot row spacing, 24 rows wide. This is one-fifth of an acre.

2. Mix 6 pints of 'Dieldrex' with water and make up the volume to 10 gallons of spray solution. Pour two gallons in the mist-blower tank.

3. The machine should be set to spray two gallons in 12 minutes. The labourer walks in every other row, up and down the plot, *i.e.* 1st row up, 3rd row down, 5th row up, and so on. He thus has 12 paths of 30 yards to do and should

take one minute for each path (30 yd/min.=approx. 1 m.p.h.). This is a slow walking space and gives him plenty of time to direct the spray. On each 30-yard path he directs the spray to cover four rows, two on either side of him. On the next path he covers the two rows on his right *again* from the opposite direction, thus ensuring that all the bushes are sprayed from both sides. He directs the lance forwards and downwards so that the spray impacts six to ten feet ahead and away from him, and he moves the lance slowly from side to side across an arc of about 90°, whilst walking slowly up the plot. If there is a little spray left at the end of the plot, he can walk back on every 4th row distributing it over the plot.

4. It will be noted that the prunings can be stacked well down on the alternate rows on which the spraying labourer does not walk. It seems likely in many instances, that the prunings can be placed there directly by the pruners with very little extra labour. They should be pressed as well down as possible, so that they do not interfere with the spray mist.

5. After completing one plot, two of the stakes can be moved on up the rows 30 yards and the spraying of the next plot done, and so on. Bring the refill to the sprayer in a can (we use polythene bottles) and refill on the spot without stopping the engine (slow it down) but do this on the ground, not on the labourer's back so that there is no danger of spilling it over him.

6. The marking of the plots with four stakes and two 30-yard long pieces of rope really takes very little time and seems well worth while as a means of ensuring that everything is sprayed. It is easy with a watch (better a stopwatch) to see whether the labourer is going faster or slower than the one minute per path. Train him to respond to a few simple hand signals, because of the noise of the engine, *e.g.* four signals which mean 'stop and turn-off', 'a little faster', 'a little slower', and 'go on'. The sequence of operating the machine should be—start, throttle eased up to full on, liquid on; liquid off, throttle down or off; observance of this sequence prevents spattering dieldrin about where it is not wanted. Labourers will vary in how they take to this work, but experience suggests that there are those on each estate who are capable of using and keen to use these machines; and they become very good at timing. The total day's work can actually be easier for them than knapsack spraying; nevertheless, more is achieved.

7. Other timings can be worked out to suit local convenience; that given above is only a generally convenient example. The method can also be applied to contour planting. However, whereas the labourer may have to go even slower than 30 yard/min on very steep ground, he should not go very much faster in any circumstances or he will not have time to direct the spray. In the above example, the actual spraying time for one acre is 60 minutes, which, with speedy refilling, means that it should be possible easily to do three or four acres a day with one machine taken alternately by two labourers.

8. It is not considered that the hazard to the spray operator is appreciably greater than with normal spraying, although there is more liability to breathe in droplets. However, no eye-shields or face masks tested have proved satisfactory and any protective devices or clothing that overheat the labourer are not to be recommended. Observe the precautions given in Section 3.6, especially the use of soap and water; it is strongly recommended that light cotton spraying clothes be provided, to cover as much of the skin as possible, and that these be washed twice a week; cotton denim overalls are ideal.

DDT spraying for Tortrix

The results obtained by mist-blowing DDT for the control of Tortrix have been good, as with nettle grubs (Cranham and Fernando, 1960). We use the same dose per acre as for high volume, 4–6 pints, made up with water to 5–7½ gallons of spray fluid.

Referring to the example of the spraying method used for dieldrin, the following details may be applied, with the same machine output of 2 gallons in 12 minutes, speed of walking 30 yards per minute, and assuming the row spacing is 4 feet.

Light machines of about 1 *h.p.:* the labourer travels every third row; use 4–6 pints in 7½ gallons per acre. The spraying time for one acre is 40 minutes.

Machines of about 3 *h.p.:* the labourer travels every fourth row; use 4–6 pints in 5 gallons per acre. The spraying time for one acre is 30 minutes.

The direction of the lance is the same as for spraying dieldrin.

Recommendation

We consider that experience with mist-blowing dieldrin and DDT has advanced far enough for planters to try it on a limited scale and gain experience of the method, especially where high-volume spraying is awkward. Only where planters have already obtained proven good results do we suggest that it could be adopted as a routine.

7.2 The use of lime with dieldrin

We have had a number of enquiries as to whether Dieldrex can be mixed with lime ('Limbux', I.C.I. (Export) Ltd.) and retain full activity. 'Dieldrex' and 'Limbux' are chemically compatible, but it does not follow that the biological activity of the 'Dieldrex' is unimpaired. This point is being checked, and no recommendation can yet be made.

Apart from the convenience of using them together where both are needed, the 'Limbux' shows very clearly where the 'Dieldrex' deposit is, and so is an excellent aid to supervision. Even when 'Limbux' is not required for mossing, there may be considerable point in adding it as a marker at a reduced rate (say ½ cwt. per acre instead of the 1–2 cwt. used for mossing). The cost per hundredweight is about Rs. 17/-. It is very unlikely that any other substance can be found which will be nearly as effective for this purpose at an economic rate. Work on this point is going on and a recommendation will be made if possible.

7.3 Other insecticides

The T.R.I. is not ignoring the possibilities for other insecticides in the control of Shot-hole Borer, in the hope that a material may be found which is effective, and which does not have undesirable side-effects, and which may also be used if necessary on the frames of tea in plucking. There is no immediate promise in this direction.

Superintendents are sometimes asked by chemical firms and agencies to try out other insecticides for the control of Shot-hole Borer. In our view, this is usually a waste of the superintendent's time, and there are dangers. In any event, if you are very keen to try something new, please consult the T.R.I.

8. Summary of important do's and don'ts

For the chemical control of Shot-hole Borer in tea, dieldrin may be used at six pints of 'Dieldrex' in about 100 gallons of water per acre sprayed on the bush frames just after pruning.

DO 1. Spray very thoroughly and on dry bark only.
2. Train the labour and see that supervision is thorough.
3. Enforce common-sense precautions in handling dieldrin.
4. Spray DDT just after tipping to prevent Tortrix outbreaks.
5. Be vigilant in looking for Tortrix and other side-effects.

DON'T 1. spray when the buds have begun to break.
DON'T 2. spray tea in plucking at any time.
DON'T 3. allow drift to contaminate tea in plucking.

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ATTENTION!

Shot-hole Borer and Tortrix

In connection with the provisional recommendations made for shot-hole-borer control in the December number of the Tea Quarterly, we wish to draw the special attention of superintendents, visiting agents, and agency houses to certain points in connection with Tortrix outbreaks arising from the use of dieldrin.

A very few instances have come to our attention where there has been excessive trouble from Tortrix arising from too large-scale dieldrin spraying within a few months, the use of insufficient dosages of DDT, and other factors.

1. It would seem wise that estates should restrict dieldrin spraying to *not more than half their acreage in any one year*, and not more than a quarter their acreage in any one period of six months. Too extensive spraying could conceivably result in localised depletion of the parasite of Tortrix.

2. Estates are requested to control Tortrix with DDT at the *full rate of 4-6 pints* in 50 or more gallons of water per acre, and *not to use reduced rates* of DDT.

3. If control of Tortrix with DDT is not satisfactory, please report the matter to the Tea Research Institute *without delay.*

4. Please read the recommendations *carefully* before proceeding with spraying dieldrin or DDT.

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15th December, 1961.

CAN SHOT-HOLE BORER OF TEA (*XYLEBORUS FORNICATUS* EICHH.) INFEST AND GROW IN SHADE TREES OF TEA?

E. Judenko

Introduction

It has been known for a long time that Shot-hole Borer of tea (*Xyleborus fornicatus* Eichh.) can be found in trees that are interplanted in tea to provide shade. It is known that the tea itself sustains a dense infestation and that shade trees are not necessary to perpetuate it. Nevertheless, since there is a good prospect of controlling the beetle in the tea itself, it is worth while examining the importance of alternative hosts for the beetle, which might now become more critical.

A distinction should be made between a host-tree that can merely be infested by the beetle—*i.e.* the beetle can make galleries in it—and a host-tree that can also sustain the growth of the beetle and thus assist in the continuation of the infestation. The presence of galleries with old female beetles in them is evidence only of the first; the presence of well-grown larvae, pupae, or young adults is evidence that the tree can act as a source of new infestation to the surrounding tea.

TABLE 1.—*Summary of literature recording (a) infestation and (b) breeding by Shot-hole Borer in certain shade trees.*

Genus	Species	Infestation	Breeding
Albizzia		Speyer, 1917	
,,	*falcata* (=*moluccana*)	Green, 1903; 1912 Speyer, 1918 Ranaweera, 1959 Judenko, 1961	Green, 1909; 1910 Rutherford, 1914 Judenko, 1961
Erythrina		Speyer, 1917 Judenko, 1961	Judenko, 1961
,,	*lithosperma*	Speyer, 1918 Light, 1927	Gadd, 1942
Grevillea		Green, 1903; 1906 Rutherford, 1914 Speyer, 1917	nil
,,	*robusta*	Speyer, 1918 Gadd, 1942 Judenko, 1961	nil
Gliricidia	*sepium*	Light, 1927 Gadd, 1942 Judenko, 1961	nil

Table 1 summarises the records of infestation of certain trees by Shot-hole Borer and also the records of breeding occuring in the same trees. It is naturally difficult, if indeed possible, to provide firm evidence that the beetle never breeds in a certain species of tree but if the number of searches made is sufficiently large and widespread over both time and space, a failure to find breeding must mean

that if it occurs at all, it is of slight importance. Thus Green (1908) stated that breeding does not occur in *Grevillea*. Gadd (1942) found young stages in various other species of trees, but only adult females in *Grevillea*. Gadd (1942) also looked for and failed to find evidence of breeding in *Gliricidia*.

It should be noted that Green (1912), found seven other species of Scolytidae, apart from *X. fornicatus*, in living, diseased, or dead stems and branches of *Albizzia*, while Green (1912) and Ranaweera (1959) found four other species of bark beetles in *Grevillea*. Careful identification of the species of beetle is essential, for these other species are of no importance to tea.

Present Observations

My observations have been made on the same four species of trees and also on *Albizzia sumatrana*. The trees were kindly identified by Mr J. E. Senaratne, Systematic Botanist, Department of Agriculture, Peradeniya; flowers and fruits of dadap were not available so the species could not be determined, though there is no reason against its being *Erythrina lithosperma*. The beetles were kindly identified by Professor K. E. Schedl, Federal Forest Research Institute of Austria.

The methods used have been partly described before (Judenko, 1960). Living branches of the trees, of diameters five-sixteenth inch to one inch (8-25 mm) were dissected and the adults were collected of all bark beetles (Scolytidae) of about the size of Shot-hole Borer. After identification of species, the sexes of *X. fornicatus* found were determined; since only the females can make galleries (Fisher *et al*, 1953), the presence of males in galleries would generally indicate that they had grown up there. The length was measured of each piece of wood examined, so that a numerical estimate of frequency could be made. The examinations were made in March, April, and July, 1959.

TABLE 2.—*Occurrence of adult beetles of Xyleborus fornicatus in shade trees*

Tree	Estate	Elevation in feet above sea level	Total lengths examined yards	Numbers of the beetles found inside branches			Average *Xyleborus fornicatus* per 100 yards
				females	males	total	
Albizzia falcata (L) Back. (*moluccana* Miq.)	Pelmadulla	700	21	16	0	16	76
	Hantane	2100	150	286	13	299	199
	Oodewella	2600	100	40	3	43	43
	Queenstown	3000	17	2	0	2	12
Erythrina sp. (dadap)	Oodewella	2600	100	8	0	8	8
	Queenstown	3000	146	50	2	52	37
	Delta	3200	75	8	0	8	11
Gliricidia sepium (Jack) Steud. (*maculata* HBK)	Pelmadulla	700	27	5	0	5	19
	Hantane	2100	150	1	0	1	0.7
	Dartry	2400	150	2	0	2	1.3
	Oodewella	2600	100	3	0	3	3
Albizzia sumatrana V. steenis.	Delta	3200	75	2	0	2	3
Grevillea robusta A. Gunn	Hantane	2100	150	0	0	0	0
	Dartry	2400	150	0	0	0	0
	Oodewella	2600	100	0	0	0	0
	Queenstown	3000	164	3	0	3	2
	Delta	3200	75	2	0	2	3

In Table 2 it will be seen that some Shot-hole Borers were found in each species of tree but that in all cases the males found were a small number compared with the females. In *Grevillea robusta*, in over 600 yards of branch, only five females were found and no males. The absence of males in this tree and also in *Gliricidia sepium* confirms Gadd (1942) in regarding these trees as not concerned in breeding. *Albizzia sumatrana* was not searched so extensively, but gave a similar picture.

At the other extreme, *Albizzia falcata* (*moluccana*) was infested 150 times as much as *Grevillea* and, though males were not common (under 5% of the females), they were commoner than both sexes together in *Gliricidia* and *Grevillea*. Dadap was less heavily infested than *A. falcata* and males were present, though as only 3% of the females.

It will be seen from Table 2 that the weighted average number of beetles per 100 yard of *Albizzia falcata* is 125. For comparison with this, in Table 10 of an earlier paper (Judenko, 1958a), the number in tea per 100 yard was 1070 beetles. In Table 9 of the same publication, the average number was 63.

Innoculation Experiments

There is some degree of uncertainty in conclusions from these observation's partly because male beetles might simply have crawled into the galleries made by the females. There is a more serious difficulty in that in some species of insects there are two or more strains which cannot be separated by examination, though they have different habits. Accordingly King (1941) inoculated certain shade trees with *X. fornicatus* taken from tea and others with beetles taken from castor. He found breeding by the beetles from castor in *Albizzia falcata*, but none by the beetles from tea in this tree, nor in dadap or *Grevillea*. Gadd (1942) thought that the failure to breed might be seasonal, in relation to the condition of the wood.

Since *Albizzia falcata* is seen in Table 2 to be the only species infested much, my experiments have been confined to this tree. Four mature tea bushes, at the same age from planting and from pruning, were dug up and planted in barrels on the verandah of the laboratory at Millawitiya Estate. They were carefully examined and found to have no open beetle galleries. In May 1960, one bush was artificially infested (Judenko, 1958) with 1,000 adults of *X. fornicatus* from *Albizzia falcata*, two bushes with 1,000 of the beetles from tea, and one bush was left as control. In July 1960, the bushes were dissected, with the results shown in Table 3.

TABLE 3.—*Results of artificially infesting tea in tubs with X. fornicatus from tea and from Albizzia falcata.*

Plants from which beetles were taken	GALLERIES			LIVE INMATES					
	Open	healed	totals	eggs	larvae	pupae	yellow adults	black adults	totals
Nil	0	2	2	0	0	0	0	0	0
Tea	44	32	76	0	3	0	1	7	11
Albizzia falcata	101	9	110	8	38	2	8	49	105

Only two healed galleries were found in the tea bush that had not been deliberately infested. The tea bush that had had beetles from *Albizzia* put on it was actually more heavily infested with all stages of the beetles and had more galleries in it than the two tea bushes that had had beetles from tea put on them. Whatever the causes of this may be, it leaves no doubt that *X. fornicatus* taken from *Albizzia falcata* can infest tea.

Acknowledgments

The author expresses his thanks to Mr J. E. Senaratne for the identification of shade trees; to Professor K. E. Schedl for identification of beetles; to Superintendents of estates for facilities afforded to carry out investigations; and to Mr C. Shanmugam, his Assistant, for help in the work.

Summary

1. Shot-hole Borer of tea (*Xyleborus fornicatus* Eichh.) has previously been found in galleries in the shade trees *Albizzia falcata* (*moluccana*), *Erythrina lithosperma*, *Grevillea robusta*, and *Gliricidia sepium*. These findings have been corroborated and also extended to *Albizzia sumatrana*, but the degree of infestation was trivial except in *Albizzia falcata* and, to a lesser extent, *Erythrina*.

2. Male adults of the beetles were found only in *Albizzia falcata* and *Erythrina*, indicating that only in those species of trees could breeding have occurred.

3. An inoculation experiment showed that *X. fornicatus* collected from *Albizzia falcata* were able to breed in tea.

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*THE NATURE OF THE PHENOLIC OXIDATION PRODUCTS IN MANUFACTURED BLACK TEA

E. A. H. Roberts

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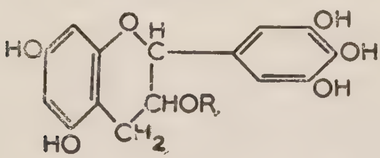
Dr E. A. H. Roberts, of the Indian Tea Association (London), was recently asked to contribute a review of his work to the Biokhimija Chainogo Proizvodstva (Biochemistry of Tea Production, Seventh Series) published by the U.S.S.R. Academy of Sciences. We are indebted to the Indian Tea Association (London) for permission to publish the original English version of this article in the Tea Quarterly.

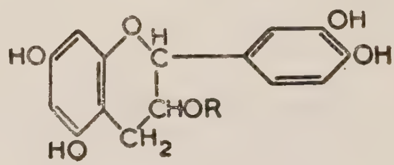
It has long been realised that the fermentation process in black tea manufacture is essentially an enzymic oxidation of polyphenolic substances, but it is only comparatively recently that the nature of the substrates undergoing oxidation has been adequately established. In this paper it is proposed to outline our present knowledge of the phenolic substances occurring in the freshly plucked tea shoots, to indicate which of these substances undergo oxidation during fermentation and to discuss the nature of the enzymic oxidation products which occur in black tea.

The phenolic substances in plucked tea-shoots

Our detailed knowledge of the phenolic substances in tea had to await the development of partition chromatography. Using this technique Bradfield and his collaborators (1,2), and Zaprometov (3) isolated several flavanols from green tea. These were identified by Bradfield as l-gallocatechin (I, R=H), dl-gallocatechin (I, R=H), l-*epi*catechin (II, R=H), dl-catechin (II, R=H), l-gallocatechin gallate (I, R=galloyl), a gallocatechin gallate (I, R=galloyl) and l-*epi*catechin gallate (II, R=galloyl). Later Bradfield & Bate-Smith (4) concluded that l-gallocatechin and its gallate should be regarded as l-*epi*gallocatechin and its gallate, a view which is now generally accepted.



(I)



(II)

The gallocatechin gallate isolated by Bradfield *et al* from green tea is not usually found in freshly plucked tea-shoots in North East India, and in the author's opinion (5) is an artefact produced by epimerisation of l-*epi*gallocatechin gallate during the course of manufacture of green tea. It also seems probable that some epimerisation of l-*epi*gallocatechin and l-*epi*catechin occurs during the manufacture of green tea with formation of l-gallocatechin and l-catechin respectively. These epimerisations probably account for the isolation of the dl-isomers from green tea, for in the unprocessed shoots plucked in North East India d-gallocatechin and d-catechin are present unmixed with the l-isomers.

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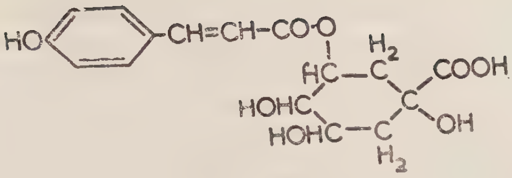
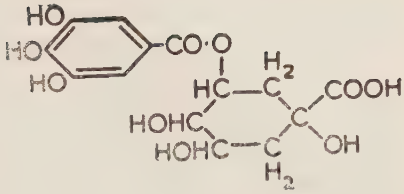
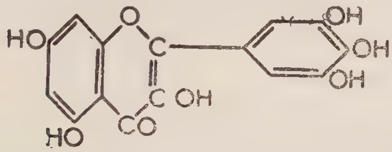


(III)
3-p-Coumarylquinic adide



(IV)
3-galloylquinic acid
(Theogallin?)

Paper chromatographic studies (6-11) have revealed the presence in tea shoots of many more phenolic substances in addition to the flavanols already mentioned. These include chlorogenic and *neo*chlorogenic acids, together with the corresponding *p*-coumarylquinic acids (III). Theogallin (IV), which ranks as one of the major constituents of tea, also belongs to this class of depsides, and previous views that it was a galloyl-quinic acid (12) have now been fully confirmed (13) although it has not yet been definitely established that the galloyl group is attached to the 3-position of the quinic acid moiety.



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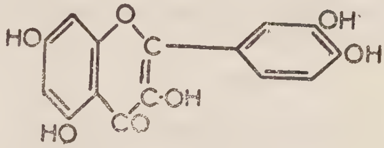
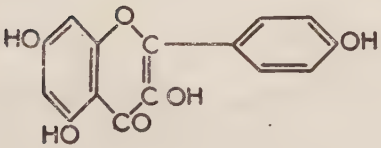
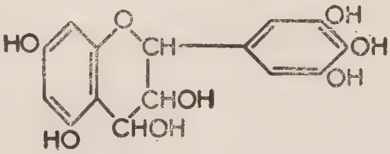


(VI)



(VII)



(VIII)

In addition to the above depsides a number of flavonols have been detected. Those identified with reasonable certainty include the 3-glucoside and 3-rhamnoglucoside of myricetin, isoquercitrin, rutin, the 3-glucoside and 3-rhamnoglucoside of kaempferol, and, in China varieties, the 3-rhamnodiglucosides of quercetin and kaempferol. Traces of myricitrin, quercitrin, and the aglycones, myricetin (V). quercetin (VI) and kaempferol (VII) have also been detected. Some teas contain leuco-anthocyanins with leuco-delphinidins (VIII) predominating over leuco-cyanidins and occasionally an uncharacterised substance IC, is found which yields gallic acid on hydrolysis. Some of the above polyphenolic substances have considerable taxonomic significance (14).

Paths of oxidation

It has been established that the oxidation of all the above flavanols, the leuco-anthocyanins, chlorogenic acid and myricetin is catalysed by the tea oxidase. It may be taken as probable that *neo*chlorogenic acid also undergoes direct enzymic oxidation. The remaining phenolic substances found in the freshly plucked shoots are not oxidised in the presence of the tea oxidase, but many of them undergo a

coupled oxidation in the presence of a suitable carrier. Thus myricitrin and theogallin are oxidised enzymically when d-catechin or l-*epi*catechin is present as a carrier. The gallocatechins are unable to function as carriers for these oxidations.

The enzymic oxidation products of one substrate, (*e.g.* l-*epi*gallocatechin gallate) may undergo further oxidation if a carrier of higher oxidation-reduction potential (*e.g.* l-*epi*catechin) is added to the system. Simultaneous oxidation of two substrates, (*e.g.* l-*epi*gallocatechin and l-*epi*gallocatechin gallate) may also yield products differing from those obtained by the oxidation of either substrate oxidised singly. It will be seen, therefore, that the oxidation of the mixture of phenolic substances in the tea shoots is likely to result in a mixture of end-products of some complexity.

The possibilities, however, are not exhausted as coupled oxidations of non-polyphenolic substances must also be considered. Any ascorbic acid present in the freshly plucked shoots will be oxidised by ortho-quinones during fermentation, but the end-products of this oxidation are unlikely to be of any great significance. On the other hand coupled oxidations of amino-acids may be of importance in view of the relatively high content of amino-acids in tea, particularly after the withering process.

It has already been demonstrated that enzymic oxidation of pyrocatechol in the presence of amino-acids leads to a condensation of the resultant o-benzquinone with amino-acids followed by coupled oxidation of the amino-acid to ammonia and the corresponding keto-acid (15). The mechanism of these chemical changes has also been considered in some detail (16). The proposed mechanism is summarised in Figure 1.

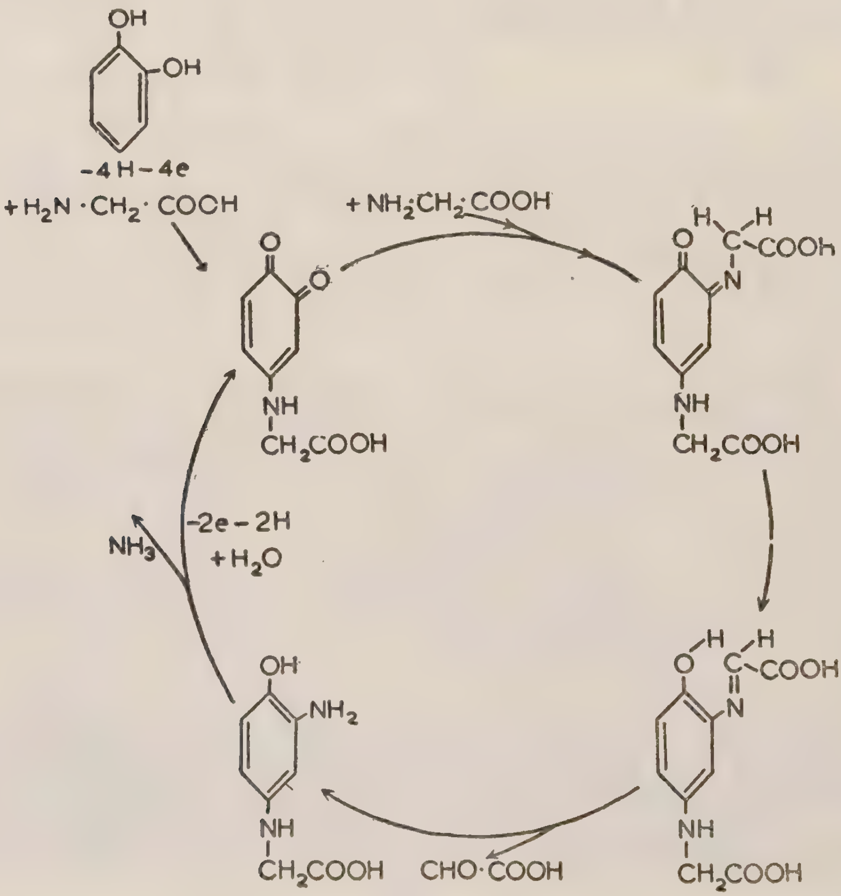
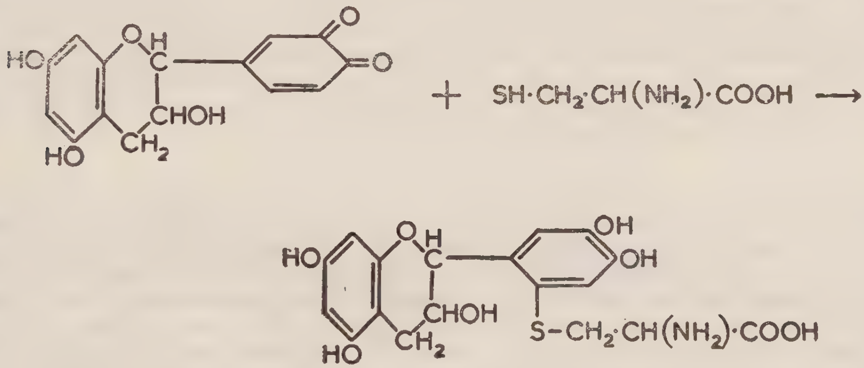


Fig. 1

It does not appear that catechins or gallocatechins can replace pyrocatechol in the above reaction scheme, for manometric studies (17) have shown that addition of amino-acids to systems composed of the tea oxidase and its substrates is without significant effect upon the rate of oxygen uptake or the total uptake realised. On the other hand Popov (18) has demonstrated that a conversion takes place of amino-acid into ammonia, carbon dioxide and the corresponding aldehyde. Only about 1% of the total amino-acid seems to undergo this conversion which accounts for the failure to demonstrate this change by manometric methods. Although the extent of amino-acid oxidation is rather limited it is considered probable that the resultant aldehydes are present in sufficient concentration to make an appreciable contribution to the liquor characters of the black tea.

Although limited coupled oxidation of amino-acids has been established there is as yet no evidence of the formation of condensation products between amino-acids and flavanol oxidation products. However it has been shown that the ortho-quinones of tea flavanols can condense with thiol groups in substances such as cysteine and glutathione (19). On oxidation of a mixture of d-catechin and cysteine the condensation presumably takes place according to the following reaction after



which oxidation of the pyrocatechol group probably takes place with the production of highly coloured end-products. Although changes of this nature have been demonstrated to take place *in vitro*, water-soluble products of this type have not been detected as yet in black tea. It is possible that orthoquinones produced in tea fermentation may become linked to thiol groups in proteins in this fashion thus accounting for the substantial proportion of polyphenolic matter which becomes water-insoluble as a result of fermentation.

Phenolic oxidation products in black tea

Two-way paper chromatographic examinations of black tea extracts (20) have shown that the main products of polyphenol oxidation show up as brown streaks of zero R_F in 2% acetic acid. The material responsible for these streaks has been separated into different fractions, but all of these fractions have very similar absorption spectra (21) and are sufficiently acidic to be extracted from solutions in organic solvents by aqueous sodium bicarbonate. These substances are referred to collectively as thearubigins (22)—the brown substances of tea—the name implies no greater extent of uniformity than is found with the melanins.

In addition to the thearubigins, five other substances were established, by paper chromatographic methods, to occur in tea in moderately high concentration. Two of these substances, originally referred to as substances X and Y (20), have

now been isolated from tea (23), and it has been estalished that Y is a gallic acid ester of X (24). It has been proposed that X and Y should be known as theaflavin and theaflavin gallate respectively; the names reflect their origin and colour. The three other substances detected (A, B and C), are colourless and it has been shown that A is probably a digallic, and B a gallic acid ester of C.

Four other substances have been detected in trace amounts, substances P, Q, R and Z. Apart from P it is unusual to be able to detect these substances unless the extracts have been subjected to further fractionation. P is probably an anthocyanidin, and Q and R have colours similar to those of the theaflavins, but these three substances make very little contribution to the total colour of a tea extract. Substance Z is colourless, and has a fluorescence very similar to that of ellagic acid, although its R_F values distinguish it from the latter substance.

The nature of the phenolic oxidation products in tea

Examination of the paper chromatograms of black tea extracts showed that all the phenolic substances detected in the freshly plucked shoots were present in black tea also, and that the only substances which appeared to have undergone any substantial reduction during manufacture were l-*epi*gallocatechin and its gallate. The oxidation-reduction potentials of these substances are lower than those of the other oxidisable polyphenols occurring in unfermented tea (25) so that it is very likely that these should be the only substrates oxidised.

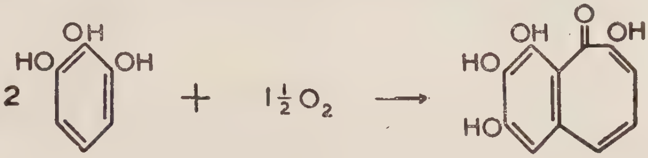
A study of the enzymic oxidation of individual tea substrates (26) has shown that l-*epi*gallocatechin gallate yields theaflavin gallate, substance A and gallic acid as the main products of reaction, together with smaller amounts of substances P, Q and Z. Substance C was found to be the main oxidation product obtained from l-*epi*gallocatechin, and when a mixture of these two substrates was oxidised the products also included theaflavin and substance B. Some substance Q was obtained on the enzymic oxidation of l-*epi*catechin gallate, but otherwise, none of the above products were obtained as a result of enzymic oxidation of flavanols other than l-*epi*gallocatechin and its gallate.

Apart therefore from the thearubigins, whose origin will be considered later, these experiments establish that the main products of tea fermentation are derived from two substrates only, l-*epi*gallocatechin and its gallate. In these experiments no free amino-acids were present in the reaction systems. It follows therefore that none of the reaction products could have been formed as a result of condensations of polyphenolic substances with amino-acids.

Despite the complex mixture of phenolic substances occurring in the freshly plucked tea-shoot it is clear that most of the oxidation products arise from two only of these substances. This considerable simplification of the problem justifies an attempt to deduce the nature of the end-products of oxidation. The first mechanisms to be considered were those in which oxidation to the ortho-quinone was followed by condensation of the ortho-quinone group with a phloroglucinol ring. Such mechanisms have already been proposed by Kursanov, Dshemuchadze and Zaprometov (27), and by Hathway and Seakins (28).

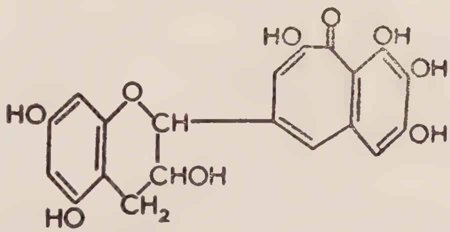
Support for such mechanisms was obtained when it was shown that the end-products of pyrocatechol oxidation (29, 30) were completely changed on addition of phloroglucinol to the system (31). It was clear that o-benzquinone condensed preferentially with phloroglucinol rather than with another molecule of o-benz quinone. However parallel experiments with pyrogallol showed that the latter

substance behaved in quite a different manner from pyrocatechol. The main product of enzymic oxidation of pyrogallol is purpurogallin whether phloroglucinol



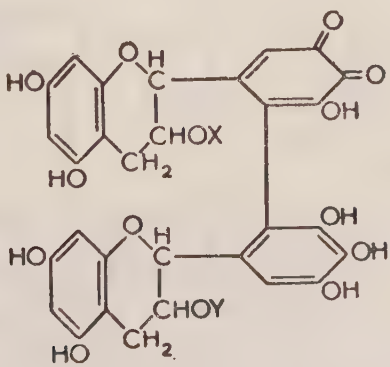
is added to the system or not, and in contrast to the experiments with pyrocatechol, condensation products of phloroglucinol with pyrogallol are only produced in trace amounts. It would therefore appear that pyrogallol groups do not resemble pyrocatechol groups in condensing readily into phloroglucinol rings, and that gallocatechins might differ from catechins in their oxidative condensations.

This view was supported by the finding that l-*epi*gallocatechin showed no tendency to combine with phloroglucinol when oxidised enzymically. On the other hand oxidation of a mixture of l-*epi*gallocatechin and pyrogallol yielded, in addition to the oxidation products of the individual substrates, a substance whose R_F values, colour reactions and absorption spectrum were consistent with its formulation as (IX).



(IX)

As l-*epi*gallocatechin underwent an oxidative condensation with pyrogallol but not with phloroglucinol it was concluded (32) that the most likely condensation to take place after enzymic oxidation of l-*epi*gallocatechin would be between two oxidised pyrogallol groups with the formation of an intermediate dimer of structure (X).

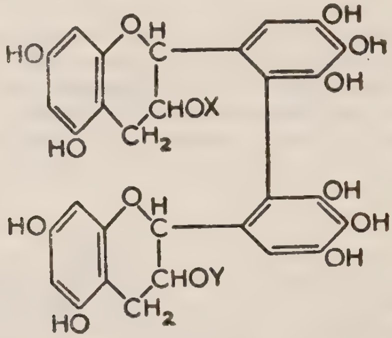


(X)

In tea fermentation the formation of three such intermediates would be expected, one arising from the condensation of two molecules of l-*epi*gallocatechin gallate (X=Y=galloyl), a second from two molecules of l-*epi*gallocatechin (X=Y=H), and a third from one molecule each of the two substrates (X=galloyl, Y=H).

At first sight it would seem that there is nothing to prevent further polymerisations of this type, but a study of three dimensional molecular models showed that steric hindrance effectively bars condensations beyond the dimer stage. With further polymerisation excluded it appeared likely that the next stages in the fermentation sequence of reactions would be either oxidations or reductions of the intermediate dimers (33).

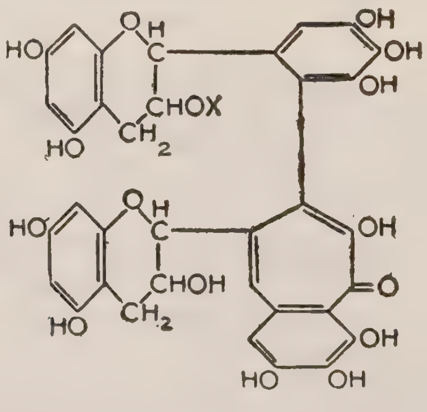
Reduction of these intermediates, with flavanol molecules functioning as hydrogen donors, would result in the formation of bisflavanols of structure (XI).



(XI)

It is suggested that substances A, B and C are bisflavanols of this structure, with A a digallate (X=Y=galloyl), and B a gallate (X=galloyl, Y=H) of C.

In considering possible oxidation mechanisms of the intermediates a special case arises when the intermediate contains at least one galloyl group. Oxidation of a galloyl group could be followed by condensation with the ortho-quinone group already present to form a benztropolone. This mechanism would lead to the formation of the two substances of structure (XII) which are tentatively identified with theaflavin (substance X) and theaflavin gallate (substance Y).

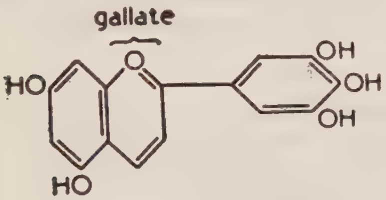


(XII)

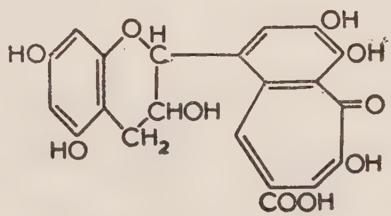
As, according to this mechanism, one galloyl group is incorporated into the benztropolone residue, oxidation of two molecules of l-*epi*gallocatechin gallate would yield a product containing one galloyl group only (X=galloyl), and with mixed substrates the end-product (X=H) would have no free galloyl group. Oxidation of l-*epi*gallocatechin would not yield a product of this type as the intermediate contains no galloyl group. The formation during tea-fermentation of only two different theaflavins, as opposed to three bisflavanols, is therefore understandable on the above hypothesis.

Degradation studies of theaflavin and theaflavin gallate are not yet sufficiently advanced for these structures to have received confirmation. Molecular formulae and absorption spectra data (23) accord well with these structures, but at present they can only be considered as working hypotheses.

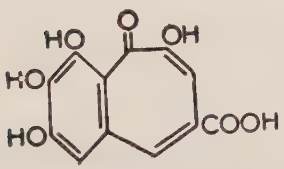
As far as the trace constituents of black tea are concerned it has been shown (21) that substance P is probably the anthocyanidin (XIII) bearing the same relation to delphinidin that luteolinidin does to cyanidin. It is probable that substance R has structure (IX) and that substance Q is a mixture of purpurogallincarboxylic acid (XIV), the 3-galloyl ester of R, and another benztropolone (XV) produced by the oxidative condensation of l-*epi*catechin with gallic acid (19, 24). Substance Z may have the structure (XVI) which would account for the similarity of its properties to ellagic acid. (33).



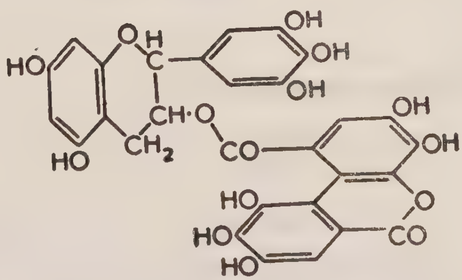
(XIII)



(XV)



(XIV)



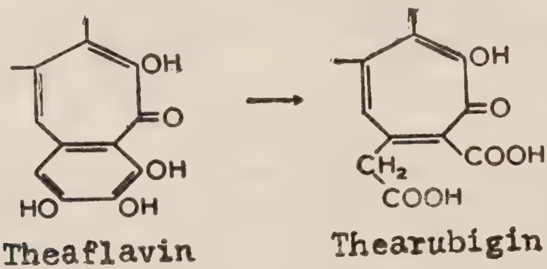
(XVI)

This brings us to a consideration of the nature of the thearubigins. The thearubigins account for from 10 to 15% of the total dry matter in Assam black teas, and must be derived largely from l-*epi*gallocatechin and its gallate, although recent results have suggested that l-*epi*catechin gallate may have become incorporated into some of the thearubigin molecules. It is doubtful whether any of the thearubigin fractions isolated from Assam teas contain nitrogen, so that these fractions probably contain no products formed by condensations of phenolic substances with amino-acids.

Methods have been developed for the colorimetric estimation of theaflavins and thearubigins (22), and with the help of these methods it has been shown that the thearubigins increase in concentration during fermentation at the expense of the theaflavins. This is an indication that theaflavins may be intermediates in thearubigin formation. More recently (19) it has been established that l-*epi*-catechin, d-catechin and l-*epi*catechin gallate can function as carriers for coupled oxidations both of theaflavin and theaflavin gallate, and that the products of these coupled oxidations behave similarly to thearubigins on paper chromatograms. Similar coupled oxidations of the bisflavanols have also been demonstrated.

In the enzymic oxidations of l-*epi*gallocatechin and its gallate the theaflavins and bisflavanols are end-products and undergo no appreciable oxidation. However the fermenting tea-leaf contains suitable carriers, in the shape of the catechins and l-*epi*catechin gallate, and it seems probable that coupled oxidations of this type occur during fermentation. There are therefore good reasons for believing that the thearubigins are oxidation products of theaflavins and bisflavanols. This dual origin would also account for the presence in Assam black teas of two main groups of thearubigins, the S I and S II fractions (20).

At present one can only speculate on the nature of the oxidation products formed, but molecular weight estimations (20, 27) show that oxidation to the thearubigin stage is unlikely to be accompanied by any further polymerisation. The acidity of thearubigins is probably due to carboxyl groups produced by the opening of pyrogallol rings. One way in which this could occur is exemplified below.



Summary and Conclusions

1. It is established that the oxidations taking place during tea-fermentation are largely confined to those affecting l-*epi*gallocatechin and its gallate.

2. The condensations of the gallocatechins after enzymic oxidation follow a different course from those of the catechins and a link between two pyrogallol groups to form a dimer is postulated. Polymerisation beyond the dimer stage is unlikely on steric grounds.

3. Three different dimers can be produced from the two substrates according to the above hypothesis. Reduction of these dimers is considered to result in the formation of the corresponding bisflavanols, identified tentatively with substances A, B and C.

4. It is suggested that oxidation of the dimers containing at least one galloyl group results in the formation of purpurogallin derivatives, identified tentatively with theaflavin and theaflavin gallate.

5. Coupled oxidations of theaflavins and bisflavanols, with catechins or l-*epi*-catechin gallate as carriers, is suggested to result in the formation of the thearubigins, the main products of tea fermentation.

6. Alternative paths of oxidation and oxidative condensation lead to the production of the trace substances P, Q, R and Z, for which possible structures are suggested.

7. Interaction of polyphenolic oxidation products with amino-acids has not led to the production of substances detectable by paper chromatography. On the other hand a limited coupled oxidation of amino-acids to aldehydes is established, and the resultant aldehydes are probably of significance in determining the aroma of tea.

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REPORT ON A WORKING-PARTY ON MIST-BLOWERS, 14th APRIL 1961.

J. E. Cranham

The use of motorized knapsack mist-blowers for spraying tea is becoming increasingly popular and it was felt that a meeting between planters using the machines, the firms selling them, and T.R.I. scientists, would be opportune. The object of the meeting was *not* to inform planters in general about this development, but to provide a forum for discussion and to clarify the issues; hence the number invited to attend was limited. The meeting, convened by Messrs A. L. Elias and J. E. Cranham, was held at Radella Club on April 14th, 1961, from 9.00 a.m. to 12.30 p.m. under the chairmanship of Dr D. L. Gunn, C.B.E., Director, T.R.I. and included members of the Experimental & Estate Committee of the T.R.I. and office-bearers of Radella Club. About 50 people attended. A demonstration of mist-blowing was arranged by the T.R.I. on Radella Estate and the various machines displayed by firms were examined and discussed.

We report herewith the information and views put before the meeting by Dr D. Mulder, Mr A. L. Elias and Mr J. E. Cranham; information on the machines kindly supplied by the manufacturers; the discussion; and the conclusions reached.

Machines

The commercial firms represented at the meeting, the machines displayed, and the manufacturers, are given below.

1. Messrs Shaw, Wallace & Hedges Ltd., P.O. Box 137, Colombo.—the 'Hurricane' and 'Hurricane Minor' (Cooper, Pegler & Co., Ltd.)

2. Messrs A. Baur & Co., Ltd., P.O. Box 11, Colombo.—the 'Micronizer 26' (Birchmeier et Cie, Switzerland).

3. Messrs United Tractor and Equipment Ltd., P.O. Box 343, Colombo.—the 'Motoblo 60' (Kent Engineering & Foundry Ltd., U.K.).

4. Messrs Mackwoods Ltd., P.O. Box 91, Colombo.—the 'Kinkelder' (Machinefabriek de Kinkelder, Holland).

5. Messrs Chatham House Ltd., P.O. Box 743, Colombo.—the 'Boss' and the 'Gnome' (Carl Platz G.M.B.H., W. Germany).

6. Messrs Raja & Peries Ltd., P.O. Box 856, Colombo.—the 'Unus' type F.R. 5 (Chiron Plant Protection Equipments, W. Germany).

7. Messrs Pest Controllers, York Building, York Street, Colombo 1.—the 'K.W.H.' type 25 (Technical Lloyd Ltd., Holland).

Information on these machines was given to the meeting. Some of the salient features are listed in Table 1 (p. 209). The costs of these machines varied from Rs 735/- to Rs 950/-, excluding discounts. All machines can be converted for dusting. Evidence on the life of machines was slender; the life of one make of machine was estimated at 3,000 working hours and another at "five years if well maintained".

Mist-blowing for blister-blight control—D. Mulder

Mist-blowing as it is carried out in other countries has achieved two things: first, a 90% saving on the volume of water used; and second, a 30–50% saving on the quantity of fungicide.

In blister-blight control, the volume has been brought down by 80%, by mist-blowing 2 gallons instead of spraying 10 gallons per acre. The quantity of fungicide used has so far stayed the same. What are the essential characteristics of mist-blowing that have enabled us to achieve such savings? They are basically that, firstly, the fungicide is carried by the air stream over a much larger area; and secondly, the droplet-size is further reduced.

These two facts lead to a much more uniform spread of the fungicide than can ever be achieved by pressurised knapsack sprayers. Uniform spread is really the critical point in our present way of spraying and this was elucidated by small-scale blister-blight trials in 1960, which showed that, on plots of 200 bushes, spraying at the rate of 2 oz per acre was almost as good as spraying at the rate of 6 oz per acre (Fig. 1, p. 210).

The range of size of spray droplets produced by a machine is important. The useful droplet-size range is chiefly 50–100 microns in diameter (a micron is 1/1000th of a millimetre). Droplets larger than this give insufficient distribution and coverage and droplets smaller than 30–40 microns tend not to impact on leaf surfaces at all but to drift away. Therefore the design of the nozzle in relation to the air output and speed is all-important. Clearly, the nozzles on these machines vary somewhat in form and in the droplet pattern they produce. We do not have facilities at the T.R.I. to study the agricultural engineering aspect of this and therefore we rely on the manufacturer to give us a reasonably correct droplet pattern. We can assess the practical result in spray distribution and in blister-blight control.

So much for what the machine should give us. Now let us see what happens when we use a machine in the field and in what way we can contribute towards the efficient use of it. Here we have to distinguish between control of insects and blister-blight control.

Blister-blight control is a peculiar job because we never aim at anything near eradication but we merely try to reduce the infection to about half or one-third of what it would be without control. So we are not doing a "thorough job" but just what is necessary to avoid too big a loss of crop. Depending on the carefulness and the training of the labourer, superintendents achieve this aim by using amounts of fungicides varying between 4 and 8 ounces per acre.

What will now be the new technique of controlling Blister Blight with a mist-blower? Has the labourer to behave in the same way in the field or is the technique of blowing a fungicide over the crop fundamentally different from the spraying technique?

According to experience with mist-blowers in other countries the fact that the fungicide is blown over a considerable distance changes the whole situation. To the movement of the labourer is now added the drift of the fungicide. With knapsack sprayers the fungicide is deposited in a rather small semicircle in front and to the sides of the sprayer. With mist-blowers, we can only make full use of the air current and obtain an even spread of the fungicide by clearly distinguishing between the two movements—the movement of the man and the movement of the air current. This can be achieved by assigning a separate task to each of them. The two movements should take care of the two dimensions of the rectangular area of several rows that we want to cover with fungicide. The forward movement of the man covers the length of the area and the movement of the fungicide covers the width of the rectangle. Therefore the blowing has to be done sideways and on one side only, depending on the direction of the wind. In this way we obtain the most uniform cover possible.

Blowing has to be done with the wind and not against it as far as that is possible in the field, in order to get the full benefit of the air current. Blowing against the wind produces too heavy a deposit on the nearest two or three rows and nothing on those further away. When the wind is strong, the fungicide drifts too far, on a single spray run, and gives too small a deposit over too many rows; but this is counterbalanced in a series of spray runs by the overlapping effect of the strong wind along the next set of rows.

With low-power mist-blowers, about six rows can normally be covered; with high-power blowers, 8–10 rows can be reached.

We have tried to illustrate the effect of sideways blowing and the result of swinging the nozzle in an arc by measuring the deposit on glass slides colorimetrically for both methods (Figures 2 and 3, pp. 211, 212).

It is only natural that the furthest rows should get less fungicide deposit than those nearby. It is our job to reduce this difference as far as possible; in other words the curve should be as flat as possible. If the curve has the form of Adam's Peak (Fig. 3), the method of spraying or the apparatus used is wrong. The best we can do is a kind of Pidurutalagala model as shown in Fig. 2.

The difference between the two methods can be judged from the difference in minimum spray deposit (+20 and +10 micrograms.)

For the moment it looks as if high-power mist-blowers are to be preferred because of the smaller droplet size they produce. It is possible that the droplet size of lower-power models can be improved by better design of the nozzle. There is however also a lower limit to useful droplet size because if the droplets are too small, they lose all their water by evaporation in the air before they settle and the resulting particles of fungicide either go up in the air like dust or fail to impact on a leaf but simply flow round it with the air.

Practical considerations—A. L. Elias

My earliest reaction to mist-blowers was prejudiced. It was said that the machines were excessively heavy and excessively noisy; that there was the risk of labourers falling over and getting burnt. I must say that, after a full season's spraying, I do not find any reason to believe in these ideas. From the purely practical view, the use of mist-blowers gave adequate protection against Blister Blight during periods of extremely adverse weather.

In order to achieve the maximum benefit from these machines, it was found that the following conditions applied:

(*a*) the use of a sunshine recorder, so as to spray only after an average of less than 4 hours sunshine for four consecutive days;

(*b*) a team of two machines and three labourers (able to complete 40 acres per day);

(*c*) the use of copper at a concentration of 4 oz per 2 gallons of water per acre sprayed in 12 to 15 minutes.

The output of liquid from each machine should be checked with a stop-watch and recorded. Output can be fixed at that desired by the use of restrictor jets fitted in the liquid feed pipe.

The organization of water-points in the field is important. It has been found that, with the use of plastic bottles (capacity one gallon), the third labourer can keep a constant supply of liquid by moving with the two spraying labourers.

When spraying, the machine should be used at full throttle with maximum engine revolutions to ensure maximum carry. The spray lance should be moved slowly across an arc from side to side and good use made of prevailing winds. The number of rows of tea sprayed at any one time will depend largely on wind velocity.

An important aspect is regular maintenance. Machines should be cleaned thoroughly after each day's spraying has been completed. The air filter should be removed and flushed out in a petrol-oil mixture. All plastic tubing should be checked periodically for cracks and the sparking plug cleaned occasionally. The tank should be flushed out with water daily.

Since decarbonization will probably be necessary at least annually, agencies selling these machines have been asked to provide this service. It is important that a full complement of spares should be carried by these firms. Certain essential spare parts, however, should be carried on estates.

A list displaying spare parts and the cost of individual items should be readily available to users of these machines. Some consideraton should be given to training operators in Colombo at the firm's cost.

Mist-blowing insecticides and dosage control—J. E. Cranham

The use of insecticides on tea is very much less than the use of copper fungicides, and we hope it will remain so. Nevertheless, for this smaller and restricted use, mist-blowers are likely to have more advantages over conventional knapsack sprayers, and to result in greater savings per acre, than they do with blister-blight spraying.

Our present recommendations for spraying insecticides against the various pests of tea with ordinary knapsack sprayers involve volumes of 50–100 gallons of water per acre. The usual principle with mist-blowing is that we employ the same dose of insecticide per acre at say 10 times the concentration in a tenth of the volume of water, *i.e.* 5–10 gall. per acre. Equally good if not better coverage of the crop is obtained because of the much larger number of smaller droplets, whose distribution is assisted by the air-flow.

I would straight away like to make very clear that mist-blowing insecticides is as different from mist-blowing copper fungicides as the two are different with conventional knapsacks. We are aiming at a high degree of control of most pests, say 95% or more; blister-blight spraying is in a sense palliative and aims at keeping infection below 35%. Also, we spray only one or two rounds of insecticide, not every plucking round as with fungicides. Consequently, spray coverage must be a great deal better, we must not miss a single bush; this means we take fewer rows at a time and we spray from both sides of the bush.

Now, I hold no brief for lashing insecticides about freely on tea. We have a most valuable inheritance of natural control of tea pests which is worth millions of rupees to the industry. This is another subject, and all I would say here is that there is about as much sense in *not* using pesticides on fields that are suffering severely from attack by pests, as there is in a man suffering from pneumonia refusing to use antibiotics. This leads me to the point: I feel certain that one reason why fields are often left to suffer is not the want of a known and tried cure, but the tediousness of the present spraying methods. In this, mist-blowers have the advantages of more rapid spraying and much smaller volumes of water required; because of the more rapid coverage, we have more choice as regards suitable dry days for spraying.

It is my view, therefore, that mist-blowing constitutes a considerable advance in rendering insecticide spraying on tea much easier.

Now, how far have we at the T.R.I. got with insecticidal mist-blowing? So far, we have in trial work on a field scale obtained highly satisfactory control of Nettle Grubs and of Tortrix with DDT, and of Yellow Mite with sulphur. Conclusions on other pests have not yet been reached, but I think it is very likely that the technique is suitable for the control of all pests of the flush and the upper maintenance foliage, including Lygus bug, *Helopeltis*, Red Spider Mite, and a number of caterpillar pests of tea and shade trees. It remains to be seen whether we can control a pest such as Scarlet Mite which is on the undersides of mature leaves. With regard to the use of dieldrin against Shot-hole Borer, our first trials have not yet yielded their full results, though initial results are promising.

We are not yet able to make any firm recommendations, though the information we have on this subject will be gladly given to planters, and we shall co-operate with those who want to use mist-blowers, as much as we can.

An important point, which does not seem to have received due attention, is the matter of dosage control. How are we to put the right dose on a given area? It is obvious that the spray output of the machine must be constant and the labourer must walk at a constant speed if the spray is to be evenly distributed. We have also found that the variable-dosage taps on many machines often in fact give a variable ouput at a single setting, and that the best system of fixing the output of the machine is to fit 'reducing jets' in the liquid-feed pipe, or to use interchangeable nozzles giving different outputs. The method of reducing jets is simpler. There should then be only a simple on-and-off tap on the lance and in this way the labourer is not able to alter the output whilst spraying.

First we decide on a spraying method and the number of rows of tea to be sprayed in one path with good coverage. Secondly we determine a reasonable working speed for the labourer which is usually between 15 and 45 yards per minute (say $\frac{1}{2}$ to $1\frac{1}{2}$ m.p.h.). We can then work out as a guide the theoretical time to spray an acre from the formulae:

(i) Rate of coverage (sq. yd per min)=speed of walking (yd per min) x no. of rows at a time x row spacing in feet ÷ 3.

(ii) Time for spraying one acre (min)=4,840 sq. yd ÷ rate of coverage (sq. yd per min).

(iii) Output rate of sprayer in gal per min=area dosage required in gal per acre ÷ time for spraying one acre (min per acre).

The actual time for spraying an acre usually turns out to be 15–20% higher than the theoretical time.

The commonest spacing between rows is four feet and some theoretical times for spraying an acre at this spacing are given in Table 2.

TABLE 2.—*Theoretical times for spraying an acre (minutes)*

These are given for a 4-foot row spacing—to calculate for any other row spacing, multiply by $\frac{4}{\text{row spacing (feet)}}$

Number of rows between paths of sprayer	Speed of walking (yards per minute)			
	15	22½	30	45
2	121	81	61	41
3	81	54	40	27
4	61	40	30	20
6	40	27	20	14
8	30	20	15	10
10	24	16	12	8

We can now correlate machine output and the speed of walking. For example if we want to spray 6 pints of DDT emulsion in 6 gallons of water/acre, and the machine is set to spray 2 gallons in 10 minutes, it will take 30 min to spray the 6 gallons; taking 8 rows at a time at 4 ft spacing, we see that to take 30 min over the job, the labourer must walk at 15 yd per min. With 4 rows at a time, he would have to walk at 30 yd/min. These are only examples and the method can be adapted to suit convenience (*see also the article in this issue on control of Shot-hole Borer—Cranham*, 1961).

We want good machines with *all* the parts well designed and strongly built. These are good machines basically, and yet on most, if not all, one comes across minor points which are not well thought out or finished. These are usually little things and seem to me a case of 'spoiling the ship for a ha'p'orth of tar'.

To the planters, I would like to say that this subject seems to provoke the most dogmatic statements. A good instance is the statement that mist-blowers are fine so long as you have a flat estate. Yet we now have machines weighing less, fully loaded, than an ordinary knapsack sprayer and the labourer can move more slowly than he has to in normal blister-blight spraying. He can literally go anywhere that he can reach with a knapsack sprayer and in fact he has to do fewer climbs on steep ground to achieve good cover. Again, it is said that they are too likely to give mechanical breakdowns and that the labourers are not up to using them. Yet they are less complex than a motor cycle. You cannot expect, however, to neglect the very simple maintenance work and not have trouble.

Mr Elias, for example, has shown that the labourers—selected men—are certainly up to it, and will in fact take a pride in the machine and what it can do. This is something of a challenge; the advantages are there if we take a little trouble.

The final decision rests with you. We may show that technically a certain method is more efficient but it still may not be generally workable or acceptable. All sorts of factors enter into it, which we shall no doubt hear about this morning. But please don't be dogmatic about it, or imagine that a generally valid conclusion can be reached by a quick practical test in the field. For our part, there is a good deal of experimental work that needs doing, and provided there is interest from you, then as far as possible we will do it. The thing at stake is your profit. We want to help reduce your C.O.P.

Discussion

Various points raised during the discussion are noted below.

1. Methods of spraying

There was discussion as to relative merits of blister-blight misting being done (*a*) with the wind, in one direction only, or (*b*) by moving the lance slowly from side to side. The meeting, including the T.R.I. staff, was divided on this issue; there has not been enough work critically comparing blister-blight control obtained by the two methods; but both give satisfactory control.

Some planters, when spraying on steep ground, had followed the practice of using the bunds of drains for paths and misting down the slope of tea. In tea in the 3rd and 4th years from pruning, the possibility of cutting back side-branches to give very narrow paths for the sprayer was also mentioned.

2. Design of machines

The designs of the machines were criticized by some planters, but it was more generally agreed that, although not specifically designed for tea, they were the only practicable development by which spraying of Ceylon tea could be mechanized and that only minor modifications were needed to adapt them for tea. Several planters referred to the need for a safety bar or frame behind the machine so that if the labourer accidentally fell, damage to the machine would be minimized; exhaust silencers should also have a guard to prevent burns. It was agreed that further silencing was desirable if it could be done without excessive loss of power, but this was doubtful.

The best combination of engine power and air output for machines for spraying tea was not known. There had been a move towards much lighter machines but were we sacrificing air-output too much?

3. Servicing

The need for good servicing facilities and supply of spare parts by the agents was strongly stressed. Three firms had arrangements for mobile workshop vans visiting estates and also Colombo workshops; others had Colombo workshops only. Breakdowns and minor faults would prejudice the adoption of these machines by estates. The necessity for the small amount of daily maintenance, which had to be done on the estate, was also pointed out.

4. Petrol-oil mixture

A few planters asked whether the oil companies could be persuaded to supply a ready-mixed petrol-oil for use in these engines, which would ensure that the correct mixture of 1: 25 oil/petrol was in fact used. In any event, agents agreed that small measures, giving the correct amount of oil for a tankful of petrol, could be supplied.

(One petroleum company has been approached by Messrs Shaw, Wallace & Hedges, Ltd. and regrets that it cannot undertake to supply petrol-oil ready mixed.—Ed.)

5. The possible confusion on some machines between the openings for the petrol-oil tank and the spray-liquid tank (where both are welded together in moulded plastic or metal) was mentioned. It was agreed these should be very different in shape and painted different colours.

6. The dangers of spray drift were discussed. There was no danger with copper fungicides which were used everywhere, but there was a danger of putting insecticides where they were not wanted, and this must be guarded against. The greatest danger was with weed-killers and these machines were not considered suitable for spraying weed-killers.

Planters questioned whether the droplet pattern could not be altered to minimize drift. If the air flow is cut down, bigger droplets are obtained, with a more restricted distribution—this, however, destroys the whole point of the machine and it is better then to use knapsack sprayers.

7. The need for proper supervision and training of labourers was stressed, and the possibility of staff being trained in the maintenance of machines by Colombo firms was mentioned. Because of the noise of the engine, there was a need for a simple sign language by the supervisor in controlling the spraying labourer.

Conclusions

The Chairman, in summing up, recorded that there was evidently a great deal of interest in this development for spraying tea, and there was general agreement by the meeting that there was a future for mist-blowers in the industry. Further work was needed on some aspects and would be taken up by the T.R.I. as far as possible. He thanked all the members for attending.

Acknowledgments

We are grateful to Dimbula A.C.C. for permission to use Radella Club for this meeting and to the Superintendent of Radella Estate for facilities for carrying out a demonstration of mist-blowing there.

TABLE 1.—*Some details of available machines*

Machine	Engine h.p.	Max. air output cu. ft/min	Weight empty lb.	Spray Tank capacity gal.	Horizontal reach of spray beam, still air	Dosage control device	Time to spray 2 gal (range in min).
'Micronizer 26'	J.L.O. 26 cc. 0.85 h.p.	180	32	2.2	20–25 ft	Variable dosage tap	6–18 min.
'Kinkelder'	J.L.O. 0.85 h.p.	154	22	2.2	Not given	Variable dosage tap or reducing jets	4½–16 min.
'Unus', Type FR5	J.L.O. 26 cc. 0.9 h.p.	212	26½	2.2	20–26 ft	Variable dosage tap	Not given
'K.W.H.' Type 25	J.L.O. 26 cc. 0.8 h.p.	140	27	1.66	20–25 ft	None, but reducing jets can be fitted	4–16 min.
'Gnome'	J.L.O. 0.85 h.p.	Not given	25	2.2	25–32 ft	Variable dosage tap	9–27 min.
'Hurricane Minor'	J.L.O. 26 cc. 0.85 h.p.	125	23½	2.2	20–25 ft	Variable dosage tap or	4–16 min.
'Hurricane'	Sachs 'Stamo' 50 1.8 h.p.	185	38½	2.2	25–30 ft	reducing jets can be fitted	3.5–16 min.
'Boss'	J.L.O., L. 60 1.8 h.p.	Not given	33	2.2	26–33 ft	—do—	4–25 min.
'Motoblo 60'	Solo Klein 3.0 h.p.	Not given	27½	2.2	Not given	—do—	2–32 min.

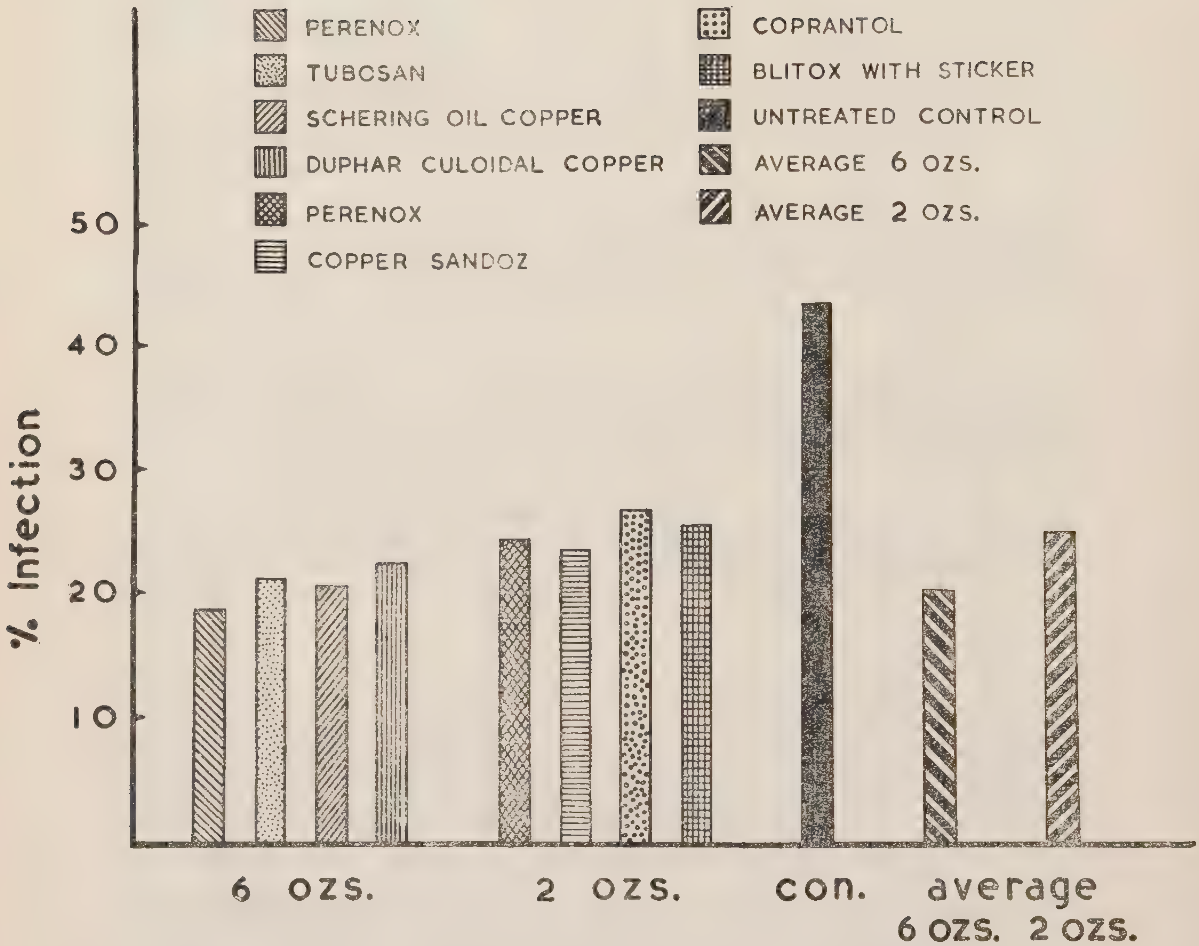

Figure 1. Comparison of blister-blight infection rates after spraying with various copper fungicides at two area-dosages, in ounces per acre. There is not much difference between the results for the two dosages when sprayed experimentally, and both are much better than not spraying.

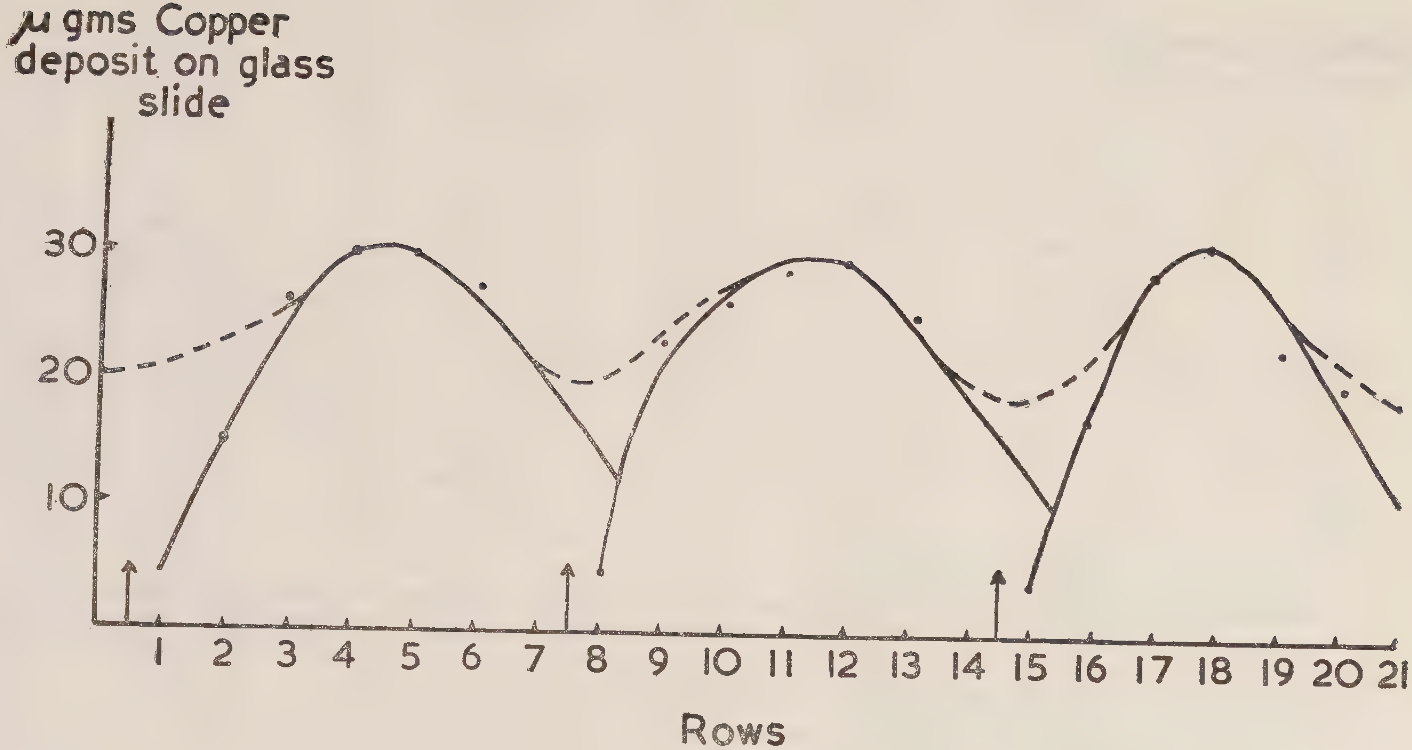

Figure 2. Deposits of copper (indicated by dots) found on glass slides at various distances from the mist-blower line, the nozzle being pointed steadily in one direction (down wind). The three sets of assessments have been combined, to show (dotted line) how the doses build up. Mist applied at intervals of seven rows. The lowest combined deposit was about 20 micrograms.

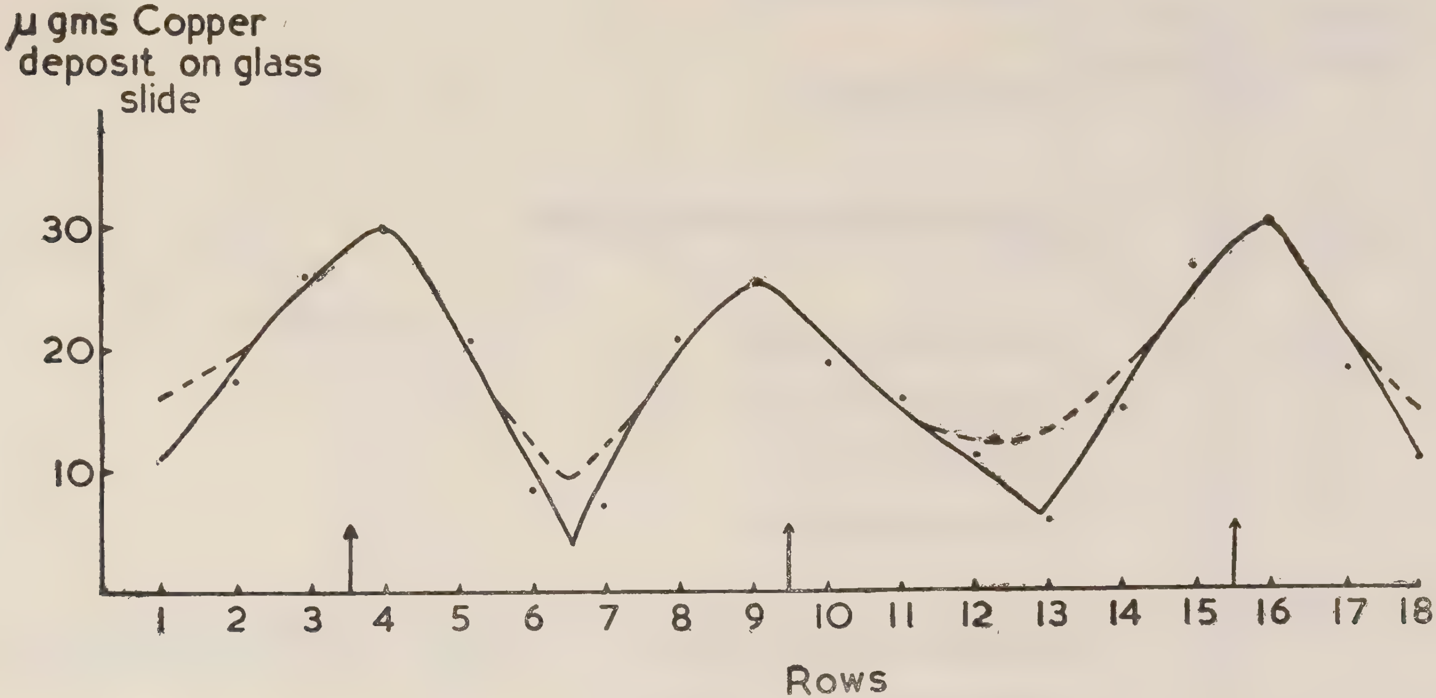

Figure 3. Deposits of copper found, as in Figure 2, except that the mist nozzle was swung from side to side and that application was made at intervals of six rows. The lowest deposit was about 10 micrograms from a slightly higher area-dosage.

POLYTHENE BAGS VERSUS BAMBOO SUPPLY BASKETS

F. H. Kehl and T. Visser

Preliminary trials of planting out cuttings direct into the field or after rooting in polythene bags have been carried out at Palmgarden and a few other estates. The results have been so successful that many estates have now stopped using bamboo supply baskets, and one firm has sold within one year 10,300 lb. of polythene tubular film to about 150 estates. At a rate of 200 bags per pound of polythene, this quantity is sufficient for over 2 million bags.

Polythene is obtainable in reels of seamless tubing, either flat or gusseted. Gusseted polythene is preferable for ease of handling, especially because it can be much more easily opened, sealed, and filled with soil. The tubing is available in many widths and gauges. We use 150-gauge, 7-8 inches long, which at a width of 6 inches gives a tube of about 3.5 inches diameter. Plants kept in the nursery longer than 12 months would require a sleeve longer than 8″.

A very convenient method of cutting sleeves is to wind the tubular film round a board (*see* Figure 1). The length of the board should correspond with the length of the tube required, whilst its width should be slightly greater than that of the film used. The film is wound about 50 times round the board and cut off at both ends. In this way 100 sleeves are produced.

One end of the sleeve is either stapled with two or three staples or heat sealed. To seal the material, it is placed on, and clamped by a steel rule on to, a heat-resisting surface so that about $\frac{1}{8}$th inch protrudes. A naked flame is then run along the protruding edge and the polythene burnt off to form the seal. Bags that are sealed should be perforated with a letter punch to allow water to drain through. A number of perforations can be made if the sealed end is folded, the number of folds depending upon the number of rows of perforations desired.

A pound of polythene tubing costs about Rs. 3/25. With a pound of 150-gauge 6-inch film it is possible to make 175 to 200 bags. A thousand staples cost Re. 1/-. A thousand bags inclusive of labour would cost between Rs. 20/- and Rs. 26/-.

Filling of polythene bags is more elaborate than that of baskets. This operation is best carried out by one labourer keeping the neck of the sleeve open whilst another fills it with soil in the same way as for baskets. A metal cylinder, resembling a Hersall cylinder and smaller than the diameter of the tube, could be used as a loading funnel. The tubular film is pulled over the cylinder and soil put in. When the tube is nearly full, the cylinder is drawn out.

The polythene bags can be arranged more neatly in the nursery than baskets on account of their uniform size. They can be held in position by placing stumps of trees or strands of wire round the bed or by earthing up along the sides of the bed. It is important, however, for the surface of the bed on which the bags are placed to be above the level of the path, in order to facilitate drainage of the bags.

Before transplanting, the tubes with the plants are placed in a box holding 12 to 16 plants in order to avoid damage during transport to the field. In the field the plants may be put out as follows:

(1) The bag is slit both lengthwise and at the bottom, then placed into the hole and the hole subsequently filled up with soil; the polythene can be either left or removed, or

(2) only the bottom end of the bag is slit and the polythene is carefully removed, in which case the bag can be used again.

The effect of using polythene bags and baskets on the growth of nursery plants was assessed in trials at Dickwella and St Coombs Estates. Cuttings of Dickwella Clone No. L.D. 4/1 were propagated in the nursery and transferred six weeks later into polythene bags or baskets; their growth was assessed one year later. At St Coombs Estate, cuttings of Clone TRI 2024 were put direct into baskets, polythene bags, or nursery beds and assessed after one year. The polythene bags (3.5 in. diameter, 7½–8 in. long) and the baskets (5 to 5½ in. in diameter and 6½–7 in. long) contained about the same volume of soil.

There were about 100 randomly chosen plants per treatment (treatments were not replicated). The dry weights of the different parts of the plants are given in Table 1.

TABLE 1.—*Effect of polythene bags and baskets (and nursery bed) on the growth of clonal plants (dry weights per plant in grams)*

A. Dickwella Estate

Plants in	Stem and leaves	Roots	Total	Top/Root Ratio
Baskets ...	3.60 (=100)	0.83 (=100)	4.43 (=100)	4.34
Polythene ...	3.92 (=109)	1.28 (=154)	5.20 (=117)	3.04

B. St Coombs Estate

Plants in	Stem and leaves	Roots	Total	Top/Root Ratio	Length of root (in.)
Baskets ...	1.26 (=100)	0.45 (=100)	1.71 (=100)	2.80	9.35 (=100)
Polythene ...	1.50 (=119)	0.51 (=113)	2.01 (=118)	2.94	11.28 (=121)
Nursery bed ...	2.30 (=183)	0.29 (= 65)	2.59 (=152)	7.88	6.68 (= 71)

It is evident from the above table that plants grown in polythene bags were better developed than those in baskets. Root growth in polythene bags was superior to that in baskets, particularly at Dickwella (Figure 2).

Cuttings planted direct into nursery beds produced more stem and leaves, but fewer roots, resulting in a high top/root ratio. High top/root ratios are often associated with a high water table and an ample nutrient supply.

Fig. 1 The winding of tubular polythene round a board to facilitate the making of bags of a required length.

Fig. 2 The growth of cuttings propagated directly in polythene bags (1) and in baskets (2) respectively. (St Coombs Estate)

Fig. 3 The state of a basket and plant (1 & 2) in comparison with that of a polythene bag and plant (3 & 4) after one year.

The advantages of using polythene instead of bamboo baskets may be summarised as follows:—

Material

1. Polythene film can be stored for a longer time and requires little storage space.

Polythene Bags

2. are cheaper;
3. may be used more than once;
4. suffer fewer losses from breakage in transit and from disintegration (see Figure 3);
5. are easier to handle and arrange in the nursery;

Growth of Plants

6. better growth;
7. better developed root system;
8. better moisture conservation, hence less watering;
9. no washing out of soil and nutrients.

MANURING OF NURSERIES:

1. EXPERIMENTS ON THE FREQUENCY AND METHODS OF APPLICATION OF INORGANIC AND ORGANIC MIXTURES

T. Visser and F. H. Kehl

Experimental

Two manuring trials were planned by us in 1959 at the suggestion of Mr Phimister, Colombo Commercial Company, and carried out by the Superintendents of Spring Valley and Dickwella estates.

The main purpose of the experiments was to compare the efficiency of partially soluble inorganic mixtures with that of a mainly organic mixture (animal meal) of the same composition. A soluble mixture has the advantage that it can be watered on the plants, whereas an organic mixture has to be dibbled in, which takes more time and labour.

The mixtures and the rates applied were:

(*a*) *Organic mixture plus Epsom Salts*, containing 5.83% N, 8.33% P_2O_5, 4.17% K_2O and 2.67% MgO, *dibbled in* at four ounces per two square yards of bed (about 100 plants).

(*b*) *Inorganic mixture*, made up from ammonium sulphate, superphosphate, potassium sulphate and magnesium sulphate, containing 5.83% N, 8.40% P_2O_5, 4.00% K_2O and 2.67% MgO; four ounces dissolved in one gallon of water and applied to two square yards of bed.

(*c*) *Inorganic mixture*, made up of the same fertilisers as in (*b*); containing 8.75% N, 6.30% P_2O_5, 8.40% K_2O and 4.00% MgO; 2.66 ounces dissolved in one gallon of water and applied to two square yards of bed.

Mixtures (*a*) and (*b*) give equivalent amounts of plant food, mixture (*c*) gives an equivalent rate of N and MgO but less P_2O_5, and more K_2O than (*a*) and (*b*). Each mixture was tried out on three different lots of plants at three frequencies of manuring—two, four and six week intervals between manuring. Plots of control plants received the same amounts of water as used for applying the inorganic mixtures. During dry days the inorganic solution was washed from the leaves and stems of the plants with some extra water, in order to prevent scorch.

Cuttings of Clone TRI 2024 were planted directly in baskets at Spring Valley in December 1959; at Dickwella, cuttings of the Dickwella Clone L.D. 9/1 were callused in beds and then transferred into baskets in April 1960. At Spring Valley, the mixtures were applied (between March and October) 14, 7 and 5 times and at Dickwella Estate (between May and November) 15, 9 and 6 times for plants manured every 2, 4 and 6 weeks respectively. On both estates the twelve treatments (including controls) were duplicated and randomized with 100 plants per plot. The results of leaf counts are summarised in Table 1.

TABLE 1.—*Average number of leaves per plant of* 12–16 *month-old plants manured with different mixtures and at various intervals (different rates over the period) on Spring Valley (SV) and Dickwella Estate (DW)* (2 × 100 *plants per treatment*)

Manurial Treatment	Application Every						Average	
	6 weeks		4 weeks		2 weeks			
	SV	*DW*	*SV*	*DW*	*SV*	*DW*	*SV*	*DW*
Water (control) ...	12.9	5.3	13.7	4.6	11.3	7.2	12.6	5.7
Organic (*a*) ...	17.8	5.6	20.3	10.3	23.0	16.0	20.4	10.6
Inorganic (*b*) ...	23.7	6.5	23.8	13.5	26.7	18.9	24.7	13.0
Inorganic (*c*) ...	20.9	4.1	22.8	7.5	29.2	19.7	24.3	10.4
Treatment average ... (without control)	20.8	5.4	22.3	10.4	26.3	18.2		

The following results can be seen from Table 1:

1. Manuring over a period of six to seven months about doubled the number of leaves in comparison with the unmanured control.

2. Plants manured every two weeks received three times more manure over the period than plants treated every 6 weeks and responded with an increase in leaf number of 26% at Spring Valley and of as much as 237% at Dickwella. Additional observations at Dickwella also showed the effect of frequent manuring on the number of plants with active shoot growth which amounted to 89, 80 and 58% of the plants manured every 2, 4 and 6 weeks respectively.

3. Judging by the number of leaves per plant, the inorganic mixtures were equally effective and at least as effective as the organic mixture (animal meal).

These experiments show the importance of manuring of nursery plants once they are rooted, and confirm the results from previous trials (Visser, Kehl & Tillekeratne, 1959), in which the same total amount of manure was given at different frequencies. These latter results are reported in detail below.

The following two manures were used on basket plants of Clones TRI 2024 and TRI 2026:

(*a*) an organic mixture (Sterameal A), containing 6.4% N, 9.2% P_2O_5, and 9.4% K_2O, used at 4 oz per 100 plants and applied every 2 weeks;

(*b*) an inorganic mixture (T. 175) made up from ammonium sulphate, superphosphate and muriate of potash, containing 11.8% N, 8.4% P_2O_5 and 8.6% K_2O, used at $2\frac{1}{4}$ oz per 100 plants and applied every 2 weeks.

The above rates gave about the same quantity of nitrogen for the two mixtures.

The two mixtures were applied to different lots of plants, randomized and replicated, over a period of 24 weeks, as follows:

(*a*) every 2 weeks at the above rates (11 times);

(*b*) every 4 weeks at twice the rates (6 times) applied in (*a*);

(*c*) every 6 weeks at three times the rates (4 times) applied in (*a*);

(*d*) every 12 weeks at six times the rates (2 times) applied in (*a*).

The plants, which were 3½ months old to begin with (May 1957), were assessed 5½ to 6 months later (Oct./Nov. 1957). The results are given in Table 2.

TABLE 2.—*The effect of manuring with an organic* (*org.*) *and an inorganic mixture* (*inorg.*) *at various intervals* (*but equal total amounts over the* 24 *weeks*) *on the growth of clonal plants in baskets* (2 *clones:* 24 *plants per clone*)

Treatments	Average height in cm.		Average no. of leaves		Average dry wt in gm*	
	org.	inorg.	org.	inorg.	org.	inorg.
Unmanured ...	22.7		11.7		1.10	
Manured every						
2 weeks ...	48.9	43.8	18.8	16.3	4.41	3.76
4 weeks ...	46.8	41.8	18.7	16.4	4.10	3.45
6 weeks ...	42.6	44.0	17.7	19.0	3.11	3.20
12 weeks ...	48.2	30.9	19.7	17.1	2.68	1.93
Average for manured plants ...	46.6	40.2	18.7	17.2	3.83	3.09

*Weight of stem + leaves cut 3″ above ground level

The results given in Table 2 show that manuring nearly doubled the height and the number of leaves of the plants and more than trebled the weight of leaf + stem. The inorganic mixture was only slightly less effective than the organic one, mainly when manuring was infrequent. The frequency of manuring had little effect on plant height and on the number of leaves but a favourable effect on the weights of stem plus leaves. Apparently plants given small amounts of fertiliser at short intervals produce either longer or thicker stems or both and bigger leaves, than do plants given correspondingly larger amounts of fertiliser at correspondingly longer intervals.

Conclusions

The trials make it clear that the application of fertiliser mixtures to nursery plants is favourable; manuring can roughly double the size of plants in 6–7 months.

The use of a (partially) soluble inorganic fertiliser mixture is preferable to that of an insoluble organic mixture of comparable composition. It is not only equally effective, but it is also easier and thus more economical to apply, *viz.* with a watering can instead of dibbling in for each plant.

As regards the composition of the fertiliser mixture this should evidently depend on soil fertility. However, the several mixtures used successfully under different conditions indicate that a mixture in which N, P_2O_5, K_2O, and MgO are in a ratio of 11: 11: 11: 4 is likely to give satisfactory results.

Reference

VISSER, T., KEHL, F. H. & TILLEKERATNE, L. M. DE W. (1959). Propagation of Tea Cuttings. I. Soil and Nutrient Requirements. *Bull. Tea Res. Inst. Ceylon* N.S. no. 1: 1–15.

MANURING OF NURSERIES:

2. T.R.I. NURSERY MANURE: A COMPLETELY SOLUBLE INORGANIC MIXTURE

J. A. H. Tolhurst and T. Visser

The foregoing paper by T. Visser and F. H. Kehl together with experience gained by the co-author of this note, has established beyond doubt that frequent and generous manuring of nurseries is beneficial. Further, that a solution of an inorganic mixture can be as efficient as an organic manure. Observations elsewhere have shown that manure scorch in nurseries is not uncommon, and therefore we feel that an effort must be made to find the simplest and safest method of manure application.

A disadvantage of superphosphate, in a mixture which is to be watered on, is that this manure always leaves a bulky, insoluble, residue of calcium sulphate. This in itself is harmless and is not needed as a plant food but it makes it difficult for the labourer to decide if he has expended enough energy to dissolve the mixture as far as it will go. Insufficient stirring will mean that undissolved sulphate of ammonia, etc. will remain in the drum, either to be wasted or to be poured out from the last few canfuls as a damaging syrup.

Mixture

To overcome this difficulty we suggest a *provisional Nursery Manure* which is completely soluble and reasonably balanced in N, P, K and Mg.

T.R.I. provisional Nursery Manure

15 parts sulphate of ammonia (20.6% N)
20 parts ammonium phosphate (20% N; 35% P_2O_5)
15 parts potassium sulphate (48% K_2O)
15 parts Epsom salts (16% MgO.)

Containing: 10.9% N; 10.8% P_2O_5; 11.1% K_2O; 4.0% MgO (approx.). The extra cost of the less common components of this mixture is not great and will be repaid by greater convenience.

Alternative Components

Ammonium sulphate/nitrate would be a suitable source of nitrogen. Urea is probably too soluble to stand up to heavy watering in nurseries, and is not recommended.

Muriate of potash carries more risk of leaf scorch than the sulphate, but is otherwise a possible alternative.

Kieserite, (24% MgO) being the dehydrated form of Epsom Salts is the less soluble of the two forms of magnesium sulphate, but is otherwise suitable.

Warning: Tea seems to be readily damaged by *sodium* (Tolhurst, unpublished data). Therefore no sodium manures, *e.g.* Chilean nitrate, should be substituted.

Application

A coarse rose is needed, as all manures contain a certain amount of sand and threads of jute from the bags.

The soil should preferably not be too wet before the solution is watered on, otherwise there will be a risk of the plant foods washing straight through. A second watering is recommended, sufficient to wash the manure solution from the leaves. As polythene sleeves are becoming increasingly popular, the following rates should be taken as giving the maximum volume of water.

Starting from the time of rooting of the cuttings:

1. 1 oz/gallon/square yard/fortnight
2. As growth becomes vigorous, this may be increased to:
   —2 oz/gallon/square yard/fortnight.

If monthly manuring is desired, these concentrations should be doubled, and in the event of weekly manuring the concentration should be halved. The stronger the solution, the more care is needed to wash the leaves immediately with clean water.

Further Experiments

A variety of suggestions can be offered, regarding the types of plant food and also methods of application. Soil type and nursery technique vary enormously, and are bound to influence the reaction to manuring. Experiments are planned to examine these details, and the *T.R.I. provisional Nursery Manure* will be subject to change whenever improvement can be made.

LETTERS TO THE EDITOR

A REVIVAL OF TEA CIDER

Introduction

Thanks to the kind help of Dr G. Stadelmann (Botanic Institute, Freiburg, Switzerland) it has been possible to start a culture of the tea fungus again at the T.R.I.

In 1932 mention was made for the first time in the Tea Quarterly (Tea Expert Bureau, Batavia, 1932) of a tea fungus being used for making tea cider in various countries, specially in Indonesia. Gadd (1933) obtained a culture from Indonesia and wrote in detail about the method of preparing the cider and the organisms connected with it. Throughout 1933 many samples were distributed but Gadd (1935?) reported that interest was gradually diminishing. In 1956 Mr B. N. Webster got into contact with Dr G. Stadelmann and obtained a dried-out specimen of the tea fungus from him. Although dried specimens are reputed to be able to revive, the samples did not grow here.

This contact was renewed by the present writer and thanks to the fact that Dr Stadelmann this time sent a sample in liquid, the tea fungus survived and started producing tea cider. Since the 12th of May, 1961, the tea cider fungus has been growing in the T.R.I. laboratory and samples are available for distribution.

The help of Mr P. V. Arulpragasam in the laboratory is gratefully acknowledged.

Here, then, are instructions for the preparation of tea cider, taken from the literature.

Ingredients

1. The "tea fungus" or fermenting agent (to be obtained from the T.R.I., Pathology Division).
2. Clean water.
3. Good quality black tea.
4. Sugar (white).
5. Glassware (1 or 2 litre vessels) or plastic containers.

Procedure

1. Add 1½–2 ounces of tea to a gallon of boiling water (3 teaspoonfulls per litre).
2. Extract for 3–5 minutes and strain the tea.
3. Add 1 lb of white sugar to one gallon of extract (or 10%) (100 gram in 1 litre).

4. Let the tea cool off to room temperature.
5. Add the tea fungus (if it does not float, fix it on a piece of cork).
6. Cover vessel (not airtight).
7. Leave to ferment for 2–3 days, depending on the temperature. At lower elevations than St Coombs a shorter time will suffice, at higher elevations a longer fermenting time is necessary. Fix time according to taste of cider.
8. Filter through double linen (table napkin).
9. Put in bottle with screw stopper.
10. After a few days an effervescent drink is obtained.

There was a report recently in a Ceylon newspaper of a man dying after drinking tea cider. We feel quite sure that the recipe given here would not lead to any human mortality, short of a consumption of several gallons per day. If there was any causal relation in the case reported, perhaps the liquor had been laced, a procedure that is not unusual in home-made drinks. Anyway, we should be glad to learn of the experiences of the many people who will doubtless try the recipe. It is understood that no duty is levied if only small quantities are made and these are not sold.

D. Mulder

Tea Research Institute of Ceylon,
St Coombs,
Talawakele.
20th September, 1961.

References

Tea Expert Bureau, Batavia (1932). Tea-Cider, a new drink in Java. *Tea Quart.* **5**: 126–127.

Gadd, C. H. (1933). Tea Cider. *Tea Quart.* **6**: 48–53.

Gadd, C. H. (1935?). Report of the mycologist for 1934. *Bull. Tea Res. Inst. Ceylon.* no. 12: 22–25.

ASSESSMENT OF CROP LOSS DUE TO A PEST

At the 12th Biennial Conference of the T.R.I. in January 1961, a question was asked about loss of crop caused by Shot-hole Borer. The answer published in the *Tea Quarterly* (**32:** 38, Question No. 20) does not precisely express my views and I feel strongly that precision is necessary in this matter.

In order to discover the loss of yield due to a pest, it is necessary to have two sets of plants that are precisely the same and under identical conditions in all respects except one, that one being the absence of pest on one set and its presence on the other, preferably in large numbers. The control of a pest by an insecticide is not identical with the mere absence of the pest; the insecticide can have effects other than simply controlling the pest in question. Thus: (1) the insecticide may also control other damaging pests and so increase yield; (2) the insecticide may also control predators of a pest in such a way as to increase that pest, (*e.g.* dieldrin and Tea Tortrix) and so reduce yield; and (3) there may be various effects of the insecticide directly on the plant or on the flora and fauna of the soil, which may in turn affect yield.

That is to say, elimination of a pest by the use of a pesticide can never tell us exactly how much damage that pest would have done. It can give us, by suitably designed and analysed experiments, an assessment of the benefits to be gained by the use of a pesticide when the pest is present, which is not necessarily the same thing.

E. Judenko

Reference

Proceedings of the 12th Biennial Conference of the Tea Research Institute of Ceylon (1961). *Tea Quart.* **32:** 38.

Tea Research Institute of Ceylon,
St Coombs,
Talawakele.
27th September 1961.

SUMMARY MINUTES OF THE MEETING OF THE BOARD OF THE TEA RESEARCH INSTITUTE OF CEYLON, HELD IN THE GENERAL COMMITTEE ROOM OF THE PLANTERS' ASSOCIATION OF CEYLON, COLOMBO, AT 9 A.M. ON FRIDAY, 1ST SEPTEMBER, 1961

Present.—Mr F. Amarasuriya (Chairman), Messrs L. F. J. Smith (Chairman Agency Section, Planters' Association of Ceylon), A. V. Richards (Director of Agriculture), M. P. Amarasuriya, J. N. Atkinson, R. C. Bois, W. H. W. Coultas, L. C. de Mel, H. R. Fernando, D. E. Hettiarachchi, R. M. Macintyre, R. D. Wedd, Dr D. L. Gunn (Director, T.R.I.), Messrs G. A. D. Kehl (Administrative Secretary) and H. J. Balmond (Secretary).

Messrs B. Mahadeva, V. G. W. Ratnayaka and R. C. Scott regretted their inability to be present.

1. Minutes of the Meeting of the Board held on 2nd June, 1961

The minutes were confirmed.

The Chairman welcomed Mr J. N. Atkinson to the Board.

2. Matters Arising from the Minutes

(1) Withered-leaf Sorting Machine

The matter was brought up for further consideration and the Board endorsed its decision to provide Rs. 7,000/- for the construction of a withered-leaf sorting machine.

(2) Building Programme

Reported that the Administrative Committee had considered the financial position arising from the increase in cess and had agreed that the deferred building contracts could now be signed. The report was received.

(3) Survey of St Coombs

A survey of St Coombs at a cost of about Rs. 4,383/- was approved.

(4) Appointment of Dr U. Pethiyagoda

Reported that the Appointments Committee on the 19th June, 1961, had unanimously recommended Dr Pethiyagoda's appointment on the research assistants' grade. The Board's approval of the recommendation had been obtained by circulation of papers.

Dr Pethiyagoda would be assuming duties on 1st December, 1961. The report was received.

(5) Dimbula-Nuwara Eliya Doctor Scheme

Circular No. AS/18 of 6th July, 1961, from the Secretary of the Planters' Association was received by the Board and the contents noted.

3. Membership of the Board and Committees

The following reports were received:—

(*a*) Membership of the Board

(1) Mr G. D. Loos, C.C.S., has been nominated to the Board by the Hon'ble the Minister of Finance in place of Mr H. E. Peries.

(2) Mr N. M. Sanders was on leave for 3 months from 12th July, 1961, and Mr J. N. Atkinson had been nominated to act for him.

(*b*) Building Committee

Mr J. N. Atkinson was acting for Mr N. M. Sanders.

The Board recorded its deep appreciation of Mr H. E. Peries's services to the Board and its Committees.

4. Finance

(1) Increase in cess

Reported that the tea research cess had been increased to one cent per pound as from 19th June, 1961. The report was received.

(2) Accounts

Reported that the Accounts of the Institute and the Estate Working account as at 30th June, 1961 had been examined and recommended for acceptance by the Administrative Committee on 4-8-61. The report was received.

(3) Supplementary Estimates

Telephones.—The Board approved a vote of Rs. 1,500/- to meet the costs of a telephone connection to the Chief Agronomist's Office.

5. Minutes of the Administrative Committee Meeting held on 4th August, 1961, and Financial Appendix

The minutes of the meeting of the Administrative Committee held on 4th August, 1961, which had been issued under cover of Circular No. 1961/177-B of 22nd August, 1961, were considered.

(1) Stocks

The Board approved the proposal for an expert survey of and the compilation of a register of equipment held by the Institute.

(2) Educational Facilities—School Bus

Reported that the service had been started on 1st September, 1961.

(3) Superintendence of Kahahengama Division

Satisfactory arrangements were made for the superintendence of this Division after purchase by the Institute.

On the proposal of Mr Coultas, seconded by Mr Macintyre, the Board approved the minutes of the Administrative Committee meeting held on 4th August, 1961, including the financial appendix.

6. Minutes of the Meeting of the Economic Committee for Instant Tea held on 3rd August, 1961

The minutes of the Economic Committee meeting held on 3rd August, 1961, which had been circulated under cover of Circular 1961/177-B of 22nd August, 1961, for the information of the Board were received.

Reported that the Director had been advised that the Cabinet had approved the project, and that the legal formalities would be completed early. The report was received.

On the proposal of Mr D. E. Hettiarachchi, seconded by Mr L. C. de Mel, the Board formally but cordially congratulated the Economic Committee on its successful achievement.

7. Draft Minutes of the Meeting of the Experimental and Estate Committee held on 5th August, 1961

The draft minutes of the meeting of the Experimental and Estate Committee which had been circulated under cover of Circular No. 1961/177-B of 22nd August, 1961, were considered.

(1) Report on Visit to Tocklai: Rotorvane

The Board accepted the recommendation of the Experimental and Estate Committee that a machine, preferably an 8″ machine, be purchased and approved a vote for this purpose.

On the proposal of Mr W. H. W. Coultas, seconded by Mr R. M. Macintyre, the Board then adopted the minutes of the Experimental and Estate Committee meeting held on 5th August, 1961.

8. Minutes of the Meeting of the Low-Country Sub-station Committee held on 4th August, 1961

The minutes of the meeting of the Low-Country Sub-station Committee held on 4th August, 1961, which had been circulated under cover of Circular 1961/117-B of 22nd August, 1961, were considered.

Reported that:—

(1) the sale agreement would be signed on November 1st;

(2) arrangements were being made for the survey of the land.

The reports were received.

The minutes of the meeting of the Low-country Sub-station Committee held on 4th August, 1961, were then adopted.

9. Staff

(1) Recruitment of Research Assistants: Scholarships

The Board considered Paper 1961/180-B and accepted in principle the scheme for awarding short-term graduate scholarships to potential research assistants to be held at the University of Ceylon, pending availability of accommodation at St Coombs.

(2) Tea Fellowships

The Board resolved that Dr R. L. Wickremesinghe be awarded a Tea Research Fellowship to be held in the United Kingdom, probably at Cambridge for two years.

(3) Expansion—Advisory Service

The Board accepted in principle the Director's proposal for the expansion of the advisory service particularly in regard to areas outside and remote from St Coombs, subject to further examination of a more detailed scheme.

(4) Appointments and Resignation

The following appointments and resignations were reported:—

(a) Appointments

Dr U. Pethiyagoda, B.Sc. (Ceylon), Ph.D. (London)—Research Assistant in Plant Physiology as from 1-12-61.

Mr W. M. W. B. Manipura, B.Sc. (Agric.) (Ceylon)—Research Assistant in Agronomy as from 1-10-61.

Mr A. J. de Croos—Technical Assistant—Plant Physiology as from 1-8-61.

N. D. Lewis—Stenographer, as from 21-6-61.

Mr M. J. Murugiah—Electrical Linesman as from 7-8-61.

(*b*) *Resignations*

Mr W. P. Chandrasekera, Accounts Clerk, as from 16-8-61.

Mr A. C. B. Pethiyagoda, Technical Assistant, Plant Physiology, as from 31-8-61.

10. Other Business

U.P.A.S.I. Scientific Conference

The Board received a report that the Director and Mr F. H. Kehl (Vegetative Propagation Officer) would be attending the U.P.A.S.I. Scientific Conference from 10th September to 16th September 1961 (inclusive).

H. J. Balmond
Secretary

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